A203.2.2.G Maintenance Agreement

SAMPLE FORM
MUST BE RETYPED
ON COMPANY
LETTERHEAD

STORMWATER/BMP
MAINTENANCE AGREEMENT

THIS AGREEMENT, made and entered into this ______ day of ______________ , 20 ___ , by and between ______________________________hereinafter called the "Landowner", and
(Insert Full Name of Owner)
the Board of Supervisors of Fauquier County hereinafter called the "County";

WITNESSETH, that

WHEREAS, the Landowner is the owner of certain real estate, more particularly described as

____

____

____

as recorded by deed in the land records of Fauquier County, Virginia, in Deed Book___________

at Page___________ , hereinafter called the "Property"; and

WHEREAS, Site Plan/Subdivision Plan ___________________________ hereinafter called the "Plan", which is expressly made a part hereof, as approved or to be approved by the County, provides for BMP's within the confines of the property; and

WHEREAS, the County and the Landowner agree that health, safety, and welfare of the residents of Fauquier County, Virginia, require/recommend that on-site Best Management Practices be constructed and maintained on the property; and

WHEREAS, the County requires that on-site Best Management Practice Facilities as shown on the Plan be constructed and adequately maintained by the Landowner;

NOW, THEREFORE, in consideration of the foregoing premises, the mutual covenants contained herein, and the following terms and conditions, the parties hereto agree as follows:

1. The on-site BMP facilities shall be constructed by the Landowner in accordance with the plans and specifications identified in the Plan.

2. The Landowner shall maintain the BMP facilities as shown on the Plan in good working order acceptable to the County.

3. The Landowner hereby grants permission to the County, its authorized agents and employees, to enter upon the Property and to inspect the BMP facilities whenever it deems necessary. Whenever possible, the County shall notify the Landowner prior to entering the Property.

4. In the event the Landowner fails to maintain the BMP facilities as shown on the Plan in good working order acceptable to the County, the County may enter upon the Property and take whatever steps it deems necessary to maintain said BMP facilities. This provision shall not be construed to allow the County to erect any structure of a permanent nature on the Land of the Landowner. It is expressly understood and agreed that the County is under no obligation to maintain or repair said facilities, and in no event shall this Agreement be construed to impost any such obligation on the County.

5. In the event the County, pursuant to this Agreement, performs work of any nature, or expends any funds in performance of said work for labor, use of equipment, supplies, materials, and the like, the Landowner shall reimburse the County upon demand, within ten (10) days of receipt thereof for all costs incurred by the County hereunder.

6. It is the intent of this Agreement to insure the proper maintenance of on-site BMP facilities by the Landowner; provided, however, that this Agreement shall not be deemed to create or effect any additional liability of any party for damage alleged to result from or be caused by nonpoint source pollutant runoff.

7. The Landowner, its executors, administrator, assigns, and any other successors in interest, shall indemnify and hold harmless the County and its agents and employees for any and all damages, accidents, casualties, occurrences or claims which might arise or be asserted against the County from the construction,

presence, existence or maintenance of the BMP facilities by the Landowner or the County.

8. This Agreement shall be recorded among the land records of Fauquier County, Virginia, and shall constitute a covenant running with the land, and shall be binding on the Landowner, its administrators, executors, assigns, heirs and any other successors in interest.

9. The Landowner, its accessors and assigns, will hold harmless and idemnify the County of Fauquier for any loss or liability resulting from the design of this site plan, in consideration of the County's approval thereof and the County's reasonably prudent measures to require and anticipate that any foreseeable impact to adjoining properties is within the limits of property management practices.

WITNESS the following signatures and seals:

(Corporate Principal) ___________________________

By: ___________________________(SEAL)

___________________________(Print Name)

[Individual Principal(s)] By: ___________________________(SEAL)

___________________________(Print Name)

STATE OF VIRGINIA
COUNTY OF ________, to wit:

I, ____, a Notary Public for said County of __________________________________, the State of Virginia, do hereby certify that __________ __________________________________ whose name(s) is/are signed to the foregoing Stormwater/BMP Maintenance Agreement, bearing date of _____ day of _______, 20___, have acknowledged the same before me in my County aforesaid.

My Commission as Notary Expires _______________________________

Given under my hand this __________________ day of ______________ , 20___.

____

Notary Public

A204 Technical Bulletins

Technical Bulletin No. 2

Virginia Department of Conservation and Recreation - Hydrologic Modeling and Design in Karst

4-5 HYDROLOGIC MODELING in KARST

Karst is a landscape in which underlying geologic strata are commonly riddles with caves, crevices, and cavities that alter “typical” surface runoff infiltration rates common in other non-karst areas. In Virginia, most karst lands are underlain by soluble limestone and dolomite, collectively referred to as “carbonate rock.

The limestone and dolomite valleys west of the Blue Ridge mountains are separated by narrow ridges largely composed of sandstone and shale. Lower ridges are often composed of sandy dolomites and limestones. Both of these terrains can exhibit extreme karst topography, with first and second order streams that abruptly, or gradually lose drainage to the cavernous subsurface, temporal streams with large subsurface drainage areas, “blind valleys” (i.e., large linear sinkholes that are often mistaken for adequate drainage ways), and *estavelles* or hydrologically-active sinkholes that normally receive drainage from surrounding areas, but also discharge water in time of flood (Jennings, 1985).

Obviously, karst areas present problems to those attempting to work with conventional hydrologic models. Typically, modeling of a karst site or watershed via SCS or other traditional methods provides poor representation of runoff rates, with regard to both flooding and over-design of conduits and stormwater management facilities. This is largely because standard hydrologic modeling methods lack allowances for losses into sinkholes, fractures, crevices or caves that may exist in the carbonate units. Neither do models typically account for the stormwater that joins surface runoff as “interflow” when the collective capacity of interconnected conduits and cavities in the subsurface is exceeded.

Pre-development runoff rates for karst areas versus non-karst areas can differ by a large percentage even when two sites exhibit similar soil and topographic characteristics. In addition, karst hydrology can be unpredictable from surface observations, in that the consistency of bedrock permeability, porosity, and stability and vary widely over a short distance. In the karst areas of western Virginia, the formation of conduits and caverns in the bedrock are directly related to the solubility of the carbonate rock, and the structural trends (bedding planes, faults, prominent fracture patterns, etc) imposed on the rock during geologic time. In the short term, karst collapses and basin fractures can occur along these trends during climactic extremes which result in flooding and subsequent rise in the water table elevation.

The identification of karst terrain in a project area should be based on local geology and soils maps, and on field verification of karst features. In some parts of the state, standard 1:24000 topographic maps show less than 50% of the karst features that can be detected with inexpensive field observation. Aerial photographs reviewed in stereo almost always provide useful information about the karst hydrology by enabling the identification of structural trends along which groundwater and surface drainage tend to flow. The presence of sinkholes, swales, sinking steams or dry stream beds, caves, and limestone/dolomite outcrops should be mapped in the earliest stages of planning a development. Initial reconnaissance should not be limited to the site, but should extend well beyond site boundaries in order to correctly identify largescale karst features. Since the modes in which surface and ground waters interact can fluctuate dramatically in response to climatic change, karst features identified through photo-interpretation and field work should be observed under a wide range of weather conditions, especially during periods of runoff, flooding, or snowmelt, to accurately represent pre-development conditions.

The following reference is an excellent source of information for local governments and citizens living in areas underlain by karst topography: Living On Karst, A Reference Guide for Virginia Communities, 1996, Virginia Department of Conservation and Recreation, Division of Natural Heritage. Terri Brown, Project Coordinator, Route 4, Box 99-J, Staunton, VA 24401 (540) 332-9239

4-5.1 Karst loss

Karst loss is a term given to surface runoff loss into bedrock strata in areas underlain by limestone formation. Unlike other calculation factors, such as curve numbers (which deal with characteristics of the land surface), a karst loss factor is intended to depict projected losses into bedrock. The determination of karst potential in any given area may be simplified by the observation of noticeable indicators such as caves, crevices, limestone outcrops, sink holes, ponds that appear to lack sufficient contributing area, and disappearing streams. In other cases, karst infiltration areas may be difficult to identify since definitive karst features are not always obvious. Generally, a lack of natural drainage way erosion or inadequately sized drainage ways (for the size of the contributing area) may be clues to karst loss. Other observations may include undersized drainage conduits that never run full.

Accounting for karst loss in the hydrologic modeling is intended to more accurately simulate actual conditions in deriving runoff rates. Mapping of a geographic area (when limited in size) may be productive in defining a karst loss zone (an area underlain by karst bedrock). However, it should be noted that the delineation of such zones should be viewed as a method for estimating karst loss, not an accurate representation of the actual site-specific karst loss rate. Accurate karst loss modeling requires **extensive** field investigation at each site under consideration to obtain comprehensive information about sub-surface strata. In many cases the expenditure necessary to fully model a site is prohibitive. Therefore, as an alternative, karst loss projections may be comparatively simple and be fairly accurate. John C. Laughland P.E., County Engineer; Jefferson County, West Virginia, has investigated karst loss modeling and the following discussion is adapted from his research. Please note that this is one method of many and more detailed investigative guidance may be presented in the future to help identify the extent of karst loss.

Projecting karst loss in hydrologic modeling of limestone requires some specific examination (field inspection) of the subject area, along with a geologic examination of the underlying strata in order to predict the extent of the karst loss zone. It should be noted that many urban development sites, being relatively limited in size, will fall exclusively in or out of a karst loss zone. In these cases, the watershed need not be split into karst and non-karst areas.

The following procedure is recommended for estimating karst loss:

1. Delineate the contributing drainage area or watershed to be studied.

2. Define any sinkhole areas within the contributing drainage area where surface drainage has no means of escaping offsite, other than downward through the karst strata (i.e. cracks, sinks, etc.). These areas can be assumed to contribute no surface discharge and can be subtracted from the contributing drainage area from Step 1.

3. Determine the amount of the contributing drainage area (from Step 2) underlain by karst strata (in percent).

4. Calculate the peak rate of runoff from the contributing drainage area using standard hydrologic methods, and reduce the calculated value by multiplying by the *Karst Loss Modification Value* (**Table 4-10**) based on the percent karst (% Karst) calculated in Step 3.

Table 4-10 (developed using the *PSU-IV Program* by G. Aron et al) provides modifiers based on the percentage of the contributing area that is underlain by karst strata. The modifiers are used to adjust the peak rate of runoff calculated using standard modeling techniques. For example, the calculated 2-year peak discharge of 12 cubic feet per second (cfs) from a drainage area that has been determined to be underlain by 80% karst zone (with no observed sinkhole areas) would be reduced as follows:

$$12 \text{ cfs} \times 0.38 = 4.5 \text{ cfs}$$

This represents a peak rate reduction of 62%. Note that as the storm frequency decreases (i.e. 2-year frequency to 10-year frequency storm) the multiplier decreases and has less affect on the result. This is due to the fact that karst exerts less of an influence as the rainfall rate increases and underground voids fill with water.

There are other potential methods that can be utilized to model Karst, such as the use of a *TYPE I* rainfall distribution within a *TYPE II* karst area or the manipulation of the Runoff Curve Number (RCN) or *Initial Abstraction* (Ia) values (when using SCS methodology). Each method of manipulation, however, has both advantages and disadvantages in accurately representing the impacts of karst topography on runoff rates.

Adjustment for karst loss is recommended only when analyzing pre-development site conditions. The premise behind karst adjustment is to better approximate actual site conditions, which produce lower peak rates of runoff than that approximated without an adjustment factor. Once development occurs, karst features may become more obliterated from extensive site grading activity. Also, the addition of impervious cover, along with construction of a surface drainage system may offset karst losses that may be present. Therefore karst adjustment for post-developed conditions is not recommended.

TABLE 4 - 10
Karst Loss Modification Values

% Karst	Storm Return Frequency		
	(2)	(10)	(100)
100	.33	.43	.50
90	.35	.46	.56
80	.38	.51	.62
70	.47	.58	.68
60	.55	.66	.74
50	.64	.73	.80
40	.73	.80	.85
30	.82	.86	.89
20	.91	.92	.93
10	1.00	.98	.97
0	1.00	1.00	1.00

4-5.2 Karst Surcharge

A topic not frequently noted in karst modeling is sinkhole surcharge . In this phenomenon, the opposite condition than that expected from karst loss occurs. Rather than dampening the runoff peak, there can be depressed surface areas, or sinkholes, that experience surcharge (flooding) during rainfall events. This is due to the connectivity of the underground conveyance network. These natural run off detention areas may or may not be significant in the overall hydrology of a watershed, but they may exert substantial impact on small sites, subjecting development in the area to inundation. A shift of detention catchment to other offsite karst areas is also possible when onsite development activity fills a sinkhole. Karst is unpredictable and changes at the surface may bring about sub-surface hydrologic modification. Due to the complexity of karst, sinkholes or surface depressions should never be filled unless a comprehensive evaluation of the feature is completed first.

4-6 INVESTIGATION, DESIGN AND REMEDIAL MEASURES FOR AREAS UNDERLAIN BY CAVERNOUS LIMESTONE

This section is adapted from the New Jersey Soil Erosion and Sediment Control Design Manual published by the New Jersey Department of Agriculture. This guidance was developed to assist conservation district personnel, land owners, and consultants in the proper procedures for addressing areas where karst topography may pose a threat to development. While the guidance is not intended as a panacea of prevention and treatment techniques, it does provide information for an initial survey of an area suspected or known to be underlain by karst topography.

4-6.1 Introduction

Percolation of surface water can cause a migration of soil into solution cavities, forming "sinkholes" at the surface. Sinkholes cause instability of the land surface and must be given serious consideration in the development of erosion and sediment control (ESC) and stormwater management (SWM) plans. Sinkhole formation is often accelerated by construction activities that modify a site's hydrology or disturb existing soil and bedrock conditions. Ground failure in karst areas is most often caused by the alteration of drainage patterns, emplacement of impervious coverage, excessive grading, and increased loads from site improvements.

An awareness of the limitations to site development posed by karst features can prevent problems, including damage to property, structures and life, and contamination of ground water. Appropriate site testing, planning, design, and remediation help to prevent sinkhole formation during site development. Conventional methods of design and engineering may be inappropriate for karst areas. Often minor modifications in the approach to site testing and design can prevent persistent and costly post-development problems.

4-6.2 Site testing for detection of potential karst-related problems

The most effective and economical approach to designing and installing a successful soil erosion and sediment control system in karst areas is to evaluate the potential for ground failure by first collecting easily obtainable information on surface and subsurface conditions prior to construction activities. To obtain geologic maps applicants may contact the Virginia Department of Mines, Minerals and Energy, Division of Mineral Resources.

Various methods are available to collect information about the bedrock and soil conditions at a proposed development site. These can range from inspecting topographic and geologic maps and aerial photographs of the site, to drilling test borings at the location of planned facilities. Professionals involved with projects in karst areas should make a special effort to observe signs of ground subsidence during development.

Site evaluation for karst features is usually carried out in two phases: (1) *preliminary site investigation*, done prior to site design and development, and (2) *site-specific investigation*, conducted once the decision is made to design a site plan and proceed with development.

Preliminary site investigation includes a review of topographic and geologic maps, soil surveys, aerial photography, and any previous technical reports prepared for the site. This phase of investigation should include a site visit, where the experienced professional studies the site terrain in an effort to locate any obvious features, such as rock outcrops, sinkholes, springs, caves, etc. The purpose of the preliminary investigation is to identify areas of concern that may require additional investigation, and to review the preliminary site design in relationship to potential problem areas. The preliminary site investigation will often result in immediate changes to the site layout to avoid future problems.

Site-specific investigation includes collecting subsurface information at sites identified as potential problem areas during the preliminary investigation. During the site-specific investigation process the professional may examine subsurface soil and geologic conditions using test pits, test borings, and geophysical instruments to evaluate the stability of soil and rock at locations of proposed site facilities. If unstable subsurface conditions are encountered, a decision can be made to proceed to remediate prior to construction or to modify the site layout to avoid problem areas. The record of findings during this phase of the investigation includes logs of test pits, probes and borings, noting evidence of cavities in soil and rock, loss of air pressure or drilling fluid during drilling, and the condition of soil and bedrock from samples collected.

A discussion of the various site investigation methods follows:

Geologic maps: Geologic maps contain information on the physical characteristics and distribution of the bedrock and/or unconsolidated surficial deposits in an area. Geologic features such as the strike and dip of strata, joints, fractures, folds, and faults are usually depicted. The orientation of strata and geologic structures generally controls the location and orientation of solution features in carbonate rock. Geologic contacts, faults, and certain fractures sets may be more prone to solution than others. The relationship between topography and the distribution of geologic units may reveal clues about the solubility of the specific rock units. Geologic maps are often available at various scales, the most common being 1:24,000. Digital geologic data may be available as well.

Aerial photography: Aerial photos are a simple, quick method of site reconnaissance. Inspection of photos can quickly reveal vegetation and moisture patterns that provide indirect evidence of the presence of cavernous bedrock. Piles of rock or small groups of brush or trees in otherwise open fields can indicate active sinkholes or rock pinnacles protruding above the ground surface. Circular and linear depressions associated with sinkholes and linear solution features and bedrock exposures are often visible when viewed in stereo image. Inspecting photos taken on more than one date can be especially valuable in revealing changes that take place over time. Images defined at wavelengths other than visible light can be useful in detecting vegetative or moisture contrasts.

Site visit: An on-site reconnaissance is an inexpensive, important step in finding potential site constraints. Although many karst features are obvious to the eye, it is an advantage to conduct the site visit with an individual knowledgeable in karst geology. Prior to the site visit field personnel should review geologic maps, topographic maps, and air photos to help anticipate where problems might be found. It is important to review drainage patterns, vegetation changes, depressions, and bedrock outcrops to look for evidence of ground subsidence. Sinkholes in subdued topography can often only be seen at close range. Disappearing streams are common in karst areas, and bedrock pinnacles that can be a problem in the subsurface will often protrude above the ground surface. A particularly simple and often overlooked part of the site visit is to interview the property owner. Often property owners can recount a history of problems with ground failure that may not be evident at the time of the site evaluation. The location of karst features should be noted on the site map for later reference. These can be compared to other information collected to assess the risk potential for karst-related problems.

Test pits: Test pit excavations are a simple, direct way to view the condition of soils that may reveal the potential for ground subsidence, and to inspect the condition and variability of the limestone bedrock surface where bedrock is sufficiently shallow. Soil texture is an important indicator of soil strength and, therefore, the ability of soils to bridge voids. An inspector should look for evidence of slumping soils, former topsoil horizons, and fill (including surface boulders, organic debris, and other foreign objects) in the test pit. Voids in the soil or underlying bedrock can be revealed. The presence of organic soils at depth is an indicator of potentially active sinkhole sites. Leached or loose soils may also indicate areas of existing or potential ground subsidence. Observations of this type should be recorded in the soil log.

Test probes: Test probes are performed by advancing a steel drill bit into the ground using an air-percussion-drilling rig. Probes can be installed rapidly and are an effective way to quickly test subsurface conditions. Penetration depths are usually less than 50 feet. During the installation of a test probe the inspector should be aware of the rate of advance of the drill bit, sudden loss of air pressure, soft zones, free-fall of the bit, and resistant zones. These observations can provide clues to the competency of the bedrock and the presence of cavities in soil or bedrock. The volume of fluid cement grout needed to backfill the probe hole can yield a measure of the size of subsurface voids encountered during drilling.

Test borings: Test borings often yield virtually complete and relatively undisturbed soil and rock samples. Borings may provide direct evidence of the presence and orientation of fractures, weathering, fracture fillings and the vertical dimensions of cavities, and provide undisturbed samples that can be subjected to laboratory testing. Use of a split inner core barrel in rock coring provides the most meaningful results, because this method collects a relatively undisturbed sample in the core barrel. Losses of drilling fluid can indicate the presence of soil or rock cavities. When drill holes are sealed, the volume of fluid cement grout placed in the drill hole can also yield a measure of the size of openings in the subsurface.

Geophysical methods: Geophysical methods can serve as a rapid reconnaissance tool to detect physical anomalies in the subsurface that may be caused by karst features. These methods are especially suited to surveying linear corridors, and are non-disruptive to the land. Geophysical data are often useful for extrapolating between locations where other sampling methods are used. Generally it is advisable to apply more than one geophysical technique, owing to the variability in physical properties of karst terrain. Geophysical methods require an experienced professional to interpret the data collected. The properties of weathered limestone, including a highly variable bedrock surface and soils with high clay content, often hinders the depth of penetration and resolution of geophysical signals and can compromise the effectiveness of geophysical surveys. Despite these limitations, geophysics can sometimes provide a cost-effective, relatively rapid means of determining the potential for problems with karst features, including the location of shallow bedrock and significant cavities in the soil or bedrock. Geophysical anomalies should be targeted for additional direct testing procedures.

4-6.3 Recommended Procedures When Karst Features Are Identified

The site investigations described above may reveal the location of suspected areas of ground subsidence. These findings should be compared to the proposed layout of site facilities. Wherever possible, facilities should be sited to avoid suspected areas of potential ground subsidence. Where relocation of facilities is not practical, remedial measures and design standards can be employed to minimize future ground failure. Remedial sealing of voids in the soil or bedrock and /or compaction of soil and rock voids may be a viable in some areas.

<u>Site Design and Construction</u>

Site design and construction procedures can be important in reducing the risk of sinkhole development. Sinkholes most often form in areas where storm-water runoff is concentrated, where bearing loads are concentrated, and where ground water is pumped in large volumes. When development is proposed consideration should be given to the following general guidelines to minimize the risk of ground failure:

> Minimize site disturbance, including cuts and fills and drainage alteration.
>
> Minimize impervious surface so as to minimize the volume of surface runoff generated.
>
> Employ storm-water management measures that minimize flow velocities and ponding to avoid erosion of over-saturated of soils.

Waterproof pipefittings and pipe-to-basin fittings to minimize underground leaks. Leaks weaken and erode soils around underground conduits.

Place foundations on sound bedrock.

Erosion and Sediment Control Facilities

The selection, design, and implementation of ESC practices in karst areas should be guided by the following objectives and should incorporate the following design elements:

The site should be designed to take maximum advantage of topography. Modifications of site topography should be minimized.

Changes to the existing soil profile, including cuts, fills, and excavations, should be minimized.

Where practical, drainage facilities should consist of embankments at or above grade. Excavation into the existing soil profile to construct swales and basins should be minimized to the degree possible.

Temporary and final grading of the site should provide for drainage of storm-water runoff away from structures.

All SWM facilities, including grassed waterways, diversions and lined waterways, should be designed to disperse the flows across the broadest channel area possible. This reduces the level of soil saturation and reduces the potential for soil movement. Shallow trapezoidal channel cross sections are preferred over parabolic or v-shaped channels.

Sediment basins and traps should be used as a last resort for sediment control in karst areas, and should be used only after other designs have been considered and rejected. The ESC plan should attempt to minimize drainage area sizes and therefore the need for basins or large traps.

Vegetative cover should be established as rapidly as possible over exposed areas. Construction scheduling should strive to minimize the time that soil excavations are open and non-vegetated. This reduces the time that the site is exposed to periods of concentrated flows as well as preventing excessive drying of soils.

Utility trenches should be back filled with in-situ soils or low permeability fill material to discourage sub-surface water flow along the trench. Clay dams may be used at intervals along the trench excavation to impede subsurface flow along the trench. Trench backfill should be compacted to prevent future settlement and ponding. Backfill densities for open areas should exceed 90% of ASTM D-1557 maxima. Densities for areas supporting structures such as roadways should equal or exceed 95% ASTM D-1557 maxima. All underground piping should have water -tight fittings.The piping should be designed to withstand some limited displacement due to the probable ground settling and/or downward migration of trench bedding material into solution features.

Stormwater Conveyance

Stormwater conveyance structures to be used in karst areas should be designed in such a way as to dissipate overland flow over the largest area possible. Every attempt should be made to avoid concentration of flows and ponding. Grassed waterways can be effective storm-water-diversion structures in karst areas. Particularly effective are waterway designs that are shallow and broad, providing maximum bottom width and wetted perimeter to disperse flow over the greatest area.

SWM Facilities

SWM facilities are particularly vulnerable to collapse in karst areas because they are designed to concentrate and detain surface-water runoff. Ponding and associated soil saturation occur where surface-runoff is concentrated. Saturation of fine-grained soils that develop on weathered limestone can cause reduction in soil strength and erosion into bedrock voids.

Methods traditionally used to reduce or eliminate excessive seepage from an impounded area may have limited success in limestone areas. Traditional sealing methods include compaction, clay blankets, bentonite treatment and flexible membrane liners. The sealing of the solution channels in bedrock beneath the basin area can reduce seepage and soil displacement into underlying voids.

When they function properly, SWM basins can be effective in removing contaminants commonly found in storm water, including heavy metals, nutrients, herbicides, pesticides, solids, and bacteria. Most of these contaminants are attenuated by sedimentation and soil filtration in the basin bottom. Sinkholes undermine the beneficial effects of basins on water quality by allowing introduction of untreated surface runoff directly to ground water. They "short-circuit" the hydraulic benefits of basins by allowing bypassing of outlet structures.

One strategy is to provide a pre-treatment which does not utilize the detention of stormwater to settle out or filter pollutants. Refer to **Minimum Standard 3.15** for manufactured water quality BMPs which can serve as pre-treatment devices or even spill containment BMPs for commercial/industrial development in karst areas. These structures will not eliminate the potential for karst collapse, however they do provide water quality benefits in order to minimize the potential for the contamination of groundwater.

SWM basin sites can be evaluated and facilities designed and retrofitted to guard against sinkhole formation and improve performance from a water-quality perspective. Testing procedures and design elements recommended to minimize detention basin failure include:

Minimize the coverage of the site by impervious surfaces, so that basin size will be minimized.

Evaluate soil texture. The basin should be constructed to minimize excessive seepage. Highly cohesive soils such as silt and clay loams may require minimum preparation of basin bottoms. Soils with low cohesive strength, such as sandy loams may require compaction and/or replacement or modification by the addition clay binders or the installation of clay or synthetic liners. Refer to **Minimum Standard 3.06**, Table 3.06-3 for clay liner specifications.

Investigate soils and bedrock below the basin for presence of voids. Repair existing voids and/or perform preventative grouting of basin substrate.

The following guidelines should be incorporated into the design and maintenance specifications of SWM basins constructed in karst topography:

• Basin profiles should be broad and flat to allow maximum dispersion of detained flow.

• Basin bottoms should be smooth to avoid ponding.

• Inlet and outlet structures should be designed to provide diffuse discharge of water; avoid concentration of flows. Under drains are preferred to provide gradual discharge of water and to avoid prolonged ponding of water.

• Repair sinkholes that occur in basin after construction.

<u>Response and Remediation of Sinkholes Occurring During Construction</u>

It is possible for sinkholes to form during construction of a project. Sinkholes that occur during construction should be repaired immediately to prevent their enlargement and associated adverse impacts. When sinkholes occur during construction the site supervisor should take the following steps:

• Report the occurrence to the plan approving authority within twenty-four (24) hours of discovery;

• Halt construction activities in the immediate area of the sinkhole until it is stabilized. Secure the sinkhole area.

• Direct the surface water away from the sinkhole area, if possible, to a suitable storm drainage system.

• Communicate proposed remediation plan to the plan approving authority. Some jurisdictions may have local requirements for notification and review as well.

• Repair any damage to ESC measures and restore ground cover and landscaping;

• In those cases where the hazard cannot be repaired without adversely affecting the ESC design, the applicant should submit contact the plan approving authority for approval of changes to the plan.

The type of repair chosen for any sinkhole depends on its location, the extent and size of the void, the type of infrastructure planned for the sinkhole area. Sinkhole sealing methods can include the use of available on-site materials, dry or wet grout, filter material and geotextiles. General recommendations and references are available from the Department of Conservation and Recreation upon request.

All sinkhole remediation activities should be under the direct supervision of a geologist, or geotechnical engineer with experience in limestone investigations and remediation practices. A certified professional should perform all borings.

Selected References

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U.S. Department of Agriculture (USDA), National Handbook of conservation practices, IV. Standards and practices, (stock no. 001-007-00903-1) Washington D.C.

(USDA manuals and handbooks can be obtained through the National Technical Information Service Research Department, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA, 22161, 703-487-4780, 703-321-8541 (fax))

Technical Bulletin No. 3

MINIMUM STANDARD 3.10E
PLASTIC CHAMBER SYSTEMS

Definition

Plastic chambers are arch-shaped, open bottom, high-density plastic structures of various sizes and related storage capacities.

Purpose

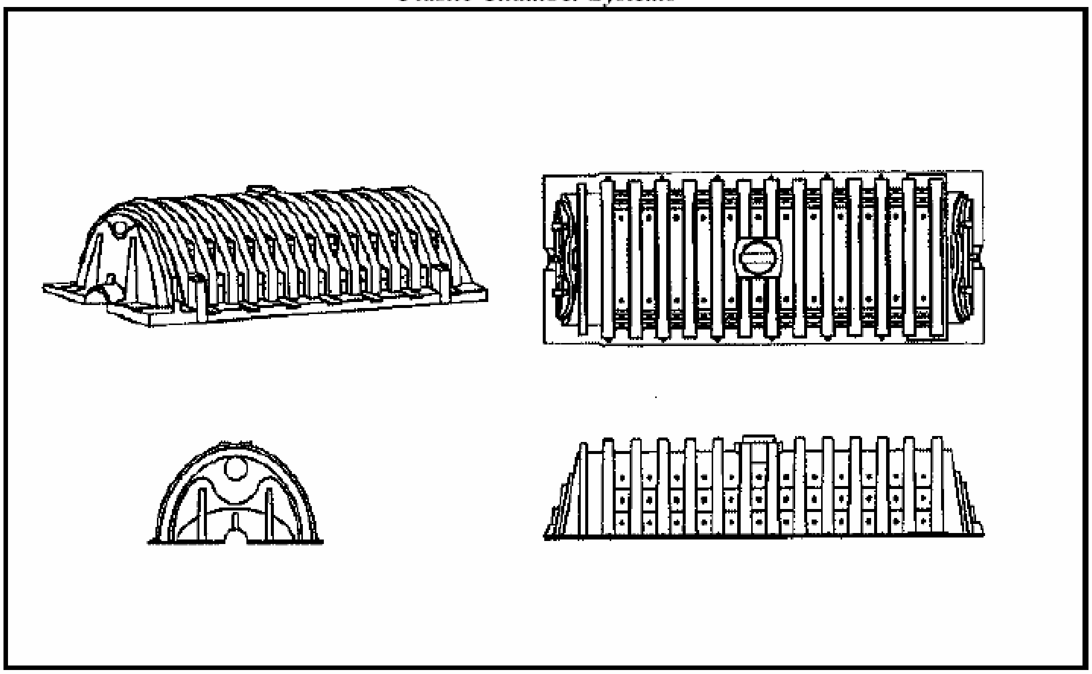
Plastic chambers are typically used as a component to a water quality BMP for providing increased subsurface storage volume for stormwater runoff. Infiltration trenches rely on the void ratio of the stone reservoir to hold the runoff while it slowly infiltrates into the subsoil. These chambers provide a large void capacity and can be used to increase the storage volume in order to store and therefore infiltrate a greater volume of runoff, or they can be used to decrease the required trench size and stone necessary to provide the equivalent required volume. The large open-bottom chamber design is also intended to provide increased water quality enhancement due to the relatively large area of bio-mat formation under the chambers, similar to the chambers' function when used for septic drain fields.

Plastic chamber systems can also be used to provide detention storage for purposes of stream channel erosion control, i.e. detention of runoff from the 1-year, 2-year, or even 10-year frequency storm.

It should be noted that these chambers can be used in a linear configuration, in place of conveyance pipe, from inlet structures to stormwater BMPs. Some of the larger chambers currently manufactured are capable of conveyance comparable to a 48 inch diameter pipe. An advantage of this alternative conveyance approach is to encourage infiltration in areas where it otherwise would not be provided.

FIGURE 3.10E – 1

Plastic Chamber Systems



Note: Refer to manufacturer specification for dimensions. Several sizes and shapes are available.

Conditions Where Practice Applies

Plastic chamber systems are presented here as a component of infiltration practices. *Drainage Area* and *Development Condition* considerations and limitations associated with Infiltration Practices and Bioretention Basins will apply here, with the exception of allowing increased drainage area size as a function of the increased storage volume provided by utilizing the chambers. These chamber systems can be placed in the subsurface storage area of infiltration trenches, roof down spout systems, porous pavement, and bioretention basins and filters.

These chamber systems are most effective where the subsoil is sufficiently permeable to provide a reasonable infiltration rate and where the water table is low enough to prevent pollution of groundwater. However, where the subsoil is not sufficiently permeable to provide a reasonable infiltration rate, plastic chamber systems can be used as subsurface detention facilities for purposes of stream channel erosion or flood control. When these systems are used for detention purposes, the economics of placing detention underground, and therefore freeing up property which would otherwise be dedicated to a detention facility, must be weighed against the initial cost of the chamber system and the long term maintenance costs of the system. In general, a pretreatment design which prevents trash, debris, or excessive sediment from entering the chambers and potentially clogging the outlet device must be provided. Underground detention of stormwater raises concerns regarding maintenance. The structure will remain full of water for extended periods if debris clogs the outlet pipe. In some cases this may result in increased opportunities for infiltration. However, if the soils are not permeable, the structure will remain full and possibly cause the next storm to bypass or backup the system.

Plastic chambers are well suited for retrofit of existing stormwater systems to provide a water quality BMP and/or runoff quantity control benefits. This is particularly applicable in highly developed areas with storm sewer systems with little or no integrated water quality BMPs or water quantity controls. Relatively small plastic chamber systems can be "tucked" into available areas, can be used to replace existing stormwater conveyance pipe, or used in place of conveyance pipe for new construction.

Plastic chambers can also be used as an integral component of other infiltration facilities. When used in place of perforated pipe in an infiltration trench, the functional life of the infiltration trench can be extended due to the open bottom area of the chambers. When used within the base area of a bioretention facility, they increase the amount of water which can be filtered through the engineered soil media during storms which produce runoff in excess of the infiltration capacity of the underlying soils.

Infiltration facilities are not recommended for areas where Karst topography is present due to the possibility of causing subsurface collapse and solution channel formation.

Drainage Area

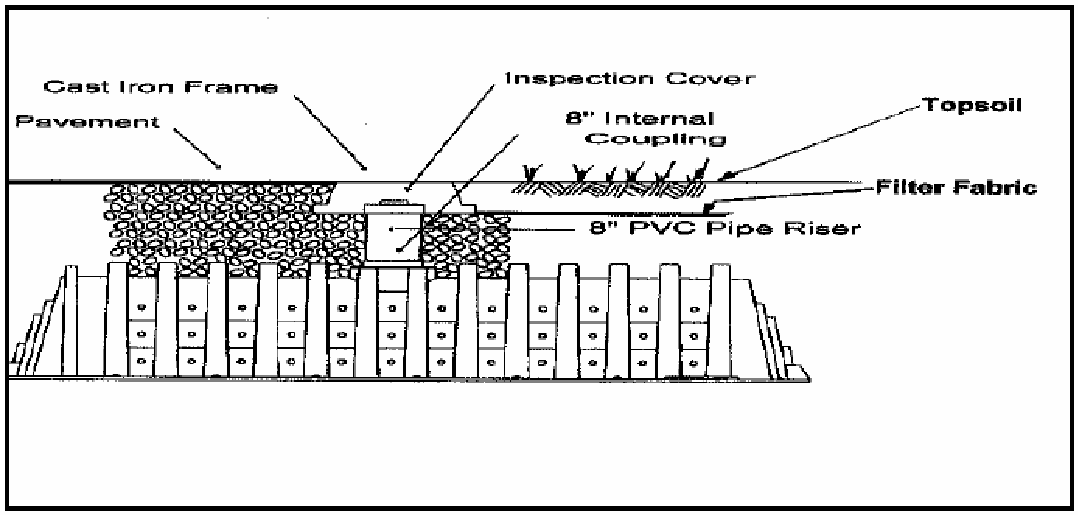
Plastic chamber systems are practical for small to medium sized drainage areas. Generally, plastic chamber systems can be used for drainage areas of up to 10 acres. For infiltration facilities which rely on the bottom surface area for infiltrating into the subsoil, the designer must check to verify that the facility will drain within the required time period. When the chambers are used under a Bioretention Filter (with an under drain system), the surface or planting area of the facility will determine the allowable drainage area.

Development Conditions

Because plastic chamber systems can be installed under trafficked or non-trafficked, open space or paved areas, they are equally well suited for low- to high- density residential, commercial, and industrial developments. They can be installed under roadways or within the roadway shoulder, or under parking lots, landscaped areas, tennis and basketball courts, play areas, or athletic fields. Smaller, multiple systems can be scattered throughout a site, under various types of land uses, each separate from the others with its own inlet structures. Due to their great flexibility in configuration and installation, plastic chamber systems can be configured in a single long line or in a rectangular or square "block" of numerous parallel rows of chambers. Other configurations are also possible by altering the number of chambers in different rows.

FIGURE 3.10E – 2

Application of Plastic Chamber System Under Porous Pavement and Open Space



Planning Considerations

Planning considerations include site conditions: soil permeability, depth to seasonal high groundwater table and bedrock, topographic conditions; sediment (and debris) control: construction runoff and urban runoff; and maintenance. Site conditions must be reviewed to verify that the site does not overlay Karst topography. Soil permeability will determine whether the plastic chambers can be utilized as a water quality BMP to promote infiltration, or simply for temporary detention of stormwater. For further discussion, refer to the **Planning Considerations** previously discussed in **General Infiltration Practices, Minimum Standard 3.10**, and **Bioretention Basin Practices, Minimum Standard 3.10.**

Design Criteria

The purpose of this section is to provide recommendations and minimum criteria for the design of plastic chamber systems. The designer must verify that the use of the selected product is in accordance with the manufacturers specifications.

Plastic stormwater chambers shall be designed to exceed the American Association of State Highway and Transportation Officials (AASHTO) recommended Load and Resistance Factor Design (LRFD) for earth loads and HS-20 live loads, with consideration for impact and multiple presences, when installed per the manufacturer's minimum requirements. It is the ultimate responsibility of the design engineer to seek verification from the plastic stormwater chamber's manufacturer that these structural requirements are met.

General

Plastic chamber systems can be designed in many configurations to meet the specific limitations of the site and the main purpose for which they are being used, e.g. temporary storage of runoff as either detention or retention, for a water quality BMP, or for stormwater conveyance. This section shall focus on the use of plastic chamber systems for temporary storage of runoff and for a water quality BMP.

The reader should refer to **Minimum Standard 3.10B: Infiltration Trench** for soils investigation requirements, topographic conditions and limitations, design infiltration rate, and maximum storage time and trench depth. (Refer to manufacturers specifications for maximum depth and loading capacities of specific product models.)

The storage volume of a plastic chamber system is calculated by summing the void space provided by the chambers and that of the surrounding stone.

Runoff Pretreatment

Preventative maintenance of subsurface storage systems, i.e. catch basins with sumps, silt diversion structures, siltation basins, etc. is in accordance with sound BMP practices. Additional chambers may be added to the system to compensate for potential loss of storage capacity. This has been achieved with some installations by replacing the inflow and/or outflow manifold pipes with chambers, and/or by using plastic chambers in place of conveyance pipe. Another approach includes segregating the first two or three chambers of each row from the rest of the plastic chamber system with high density plastic pipe connecting the upper holes in the end walls of the chambers. The first set of plastic chambers functions as a sediment trap. In this type of configuration, eight inch PVC risers can be placed on the first, and/or second chambers of the first two "up-flow" plastic chamber rows for observation and clean-out.

Backfill Material

Backfill material for plastic chamber systems should be clean 1½ to 2 inch hard granite-type stone aggregate up to at least the top of the chambers. Limestone aggregate should not be used in order to avoid the "pasting" of limestone fines that can deter infiltration. Additional aggregate of the same specifications can be added for the remaining fill to also function as the base for porous pavement (refer to **Minimum Standard 3.10D: Porous Pavement**), or to a height suitable for the addition of sufficient soil for grass and/or shrub placement.

A minimum of 6 inches of clean 1½ to 2 inch hard granite-type stone aggregate should also be placed as a base, underlying the plastic chamber system. A geotechnical investigation should be undertaken to determine if stabilization of the system base is needed.

Filter Fabric

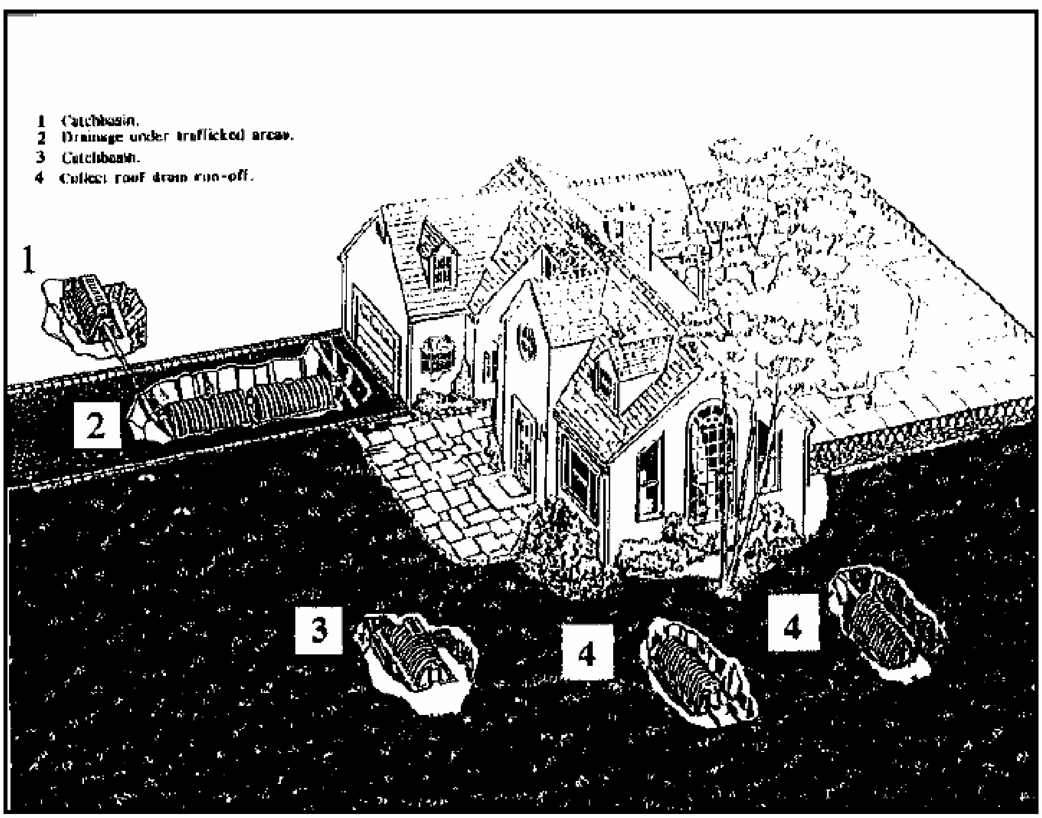
The top of the aggregate fill material should be covered with an engineering filter fabric. It is also recommended that an engineering filter fabric should be placed along the sides of the trench. Note, however, that filter fabric should **not** be placed on the trench bottom.

Overflow Channel

Because of the small drainage areas controlled by a plastic chamber system, an emergency spillway is not necessary. Due to their relatively higher void capacity, plastic chamber systems can hold relatively higher storage volumes. Plastic chamber systems, particularly with the larger chambers, are capable of retaining significant storm events without an overflow facility in many cases.

However, the overland flow path to be taken by the surface runoff, when the capacity of the plastic chamber system is exceeded, should always be evaluated. A nonerosive overflow channel leading to a stabilized watercourse should be provided, as necessary, to insure that uncontrolled, erosive, concentrated flow does not develop.

FIGURE 3.10E – 3
Example Site Design Using Plastic Chamber Systems



Observation Well

An observation well should be installed through the top of the first chambers of the first two rows receiving the runoff flow. The observation well will show how quickly the plastic chamber system drains following a storm, as well as providing a means of determining when maintenance is needed.

The observation wells should consist of perforated PVC pipe, 8 inches in diameter. They should be installed flush with the ground elevation of the plastic chamber system. The top of the well should be capped to discourage vandalism and tampering.

Construction Specifications

Accepted construction standards and specifications should be followed where applicable. Specifications for the work should conform to the methods and procedures indicated for installing earthwork, concrete, reinforcing steel, pipe, water gates, metal work, woodwork and masonry, as they apply to the site and the purpose of the structure. The specification should also satisfy any requirements of the local government.

The use and installation of plastic chamber systems must be in conformance with all manufacturers specifications. Construction of a plastic chamber system should also be in conformance with the following:

Sequence of Construction

A plastic chamber system should not be constructed or placed into service until all of the contributing drainage area has been stabilized. Runoff from untreated, recently constructed areas within the drainage area may load the newly formed plastic chamber system and/or pretreatment facility with a large volume of fine sediment. Other devises, such as temporary inlet structure silt sacks, can be used until site stabilization is achieved.

The specifications for the construction of a plastic chamber system should state the following: 1) *the earliest point at which storm drainage may be directed to the plastic chamber system, and 2) the means by which this delay in use is to be accomplished*. Due to the wide variety of conditions encountered among development projects, each project should be evaluated separately to postpone the plastic chamber system use for as long as possible.

Trench Preparation

Trench excavation and preparation, stone placement, and filter fabric placement should conform to the Construction Specifications of **Infiltration Trenches: Minimum Standard 3.10B**.

The trench should be excavated with a backhoe or similar device that allows the equipment to stand away from the trench bottom. This bottom surface should be scarified with the excavator bucket teeth on the final pass to eliminate any smearing or shearing of the soil surface. Similarly, the stone aggregate base should be placed on the trench bottom so that it does not compact or smear the soil surface. Clean, washed, broken hard granite-type stone, 1½ to 2 inches, should be used instead of limestone. Limestone and its associated fines, with prolonged exposure to water, tends to leave a pasty residue which retards infiltration.

Large tree roots must be trimmed flush with the trench sides to prevent the fabric from puncturing or tearing during subsequent installation procedures. No void between the filter fabric and the excavation walls should be present. If boulders or similar obstacles are removed from the excavated walls, natural soils should be placed in these voids before the filter fabric in installed. The sidewalls of the trench should be roughened where sheared and sealed by heavy equipment.

<u>Plastic Chamber System Placement</u>

The first chamber of each row of the plastic chamber system is placed upon the stone aggregate base and the inlet manifold system installed. Sufficient additional stone aggregate is placed around the chambers and the inlet manifold system to hold the chambers in place so that the next chamber in each row can be installed. Additional stone aggregate is then placed on these chambers to hold them in place. The process progresses until all chambers are in place and the outlet manifold, if utilized, is installed. Extra care should be taken when placing stone at the end walls at the end of each chamber row. Place stone along the centerline of the top of the end chambers to spill over the ends. Placing a large amount of stone directly against the end walls could cause them to deform.

<u>Inlet Manifold Installation</u>

An inlet manifold is used to disperse the runoff into the rows of the plastic chamber system. Under normal conditions, laterals are used off of the header pipe into every other row. Where large flash flows are anticipated, laterals should be placed into every row of the plastic chamber system. A minimum diameter for the laterals is 4 inches; 12 inch laterals are recommended for sites where typical flow conditions are anticipated. Some of the larger plastic chambers can accommodate up to 24 inch laterals.

<u>Outlet Manifold Installation</u>

An outlet manifold can be used at the down-flow end of a plastic chamber system. Construction specifications are the same as for the inlet manifold. Alternatives to an outlet manifold include placing the plastic chamber system off-line or directing chamber flow from the inlet structure at a lower elevation than the excess flow.

Stone Aggregate Fill Placement

At a minimum, place enough additional fill of the 1½ to 2 inch washed stone aggregate to just cover the chambers. The top of this fill should be level.

Backfill
Plastic chamber systems are typically backfilled with soil. Additional 1½ to 2 inch washed stone aggregate can also be used up to the minimum depth needed for soil to support a vegetative cover or for placement of the base for porous pavement.

Surface Cover Placement
For areas proposed for open space, grass, ground cover or shrubs can be used. The use of trees is not recommended to avoid possible problems with roots extending into the chambers.
For areas proposed for porous pavement, sufficient depth should be left for placement of the pavement base and the overlying pavement.

Observation Wells
Observation wells should be provided as specified in the design criteria. The depth of the well at the time of installation should be clearly marked on the well cap.

The following maintenance and inspection guidelines are not intended to be all-inclusive. Specific facilities may require other measures not discussed here.

Maintenance / Inspection Guidelines

Inspection Schedule

Same as for **Infiltration Trench, Minimum Standard 3.10B.**

Sediment Control

Sediment buildup within the pretreatment structure should be monitored on the same schedule as the observation well within the trench and chamber system.

Manufacturer Contacts

StormTech, Inc. P.O. Box 619 Old Saybrook, CT 06475 Info@StormTech.com www.stormtech.com (888) 892-2694	**CULTEC, Inc.** P.O. Box 280, 878 Federal Road Brookefield, CT 06804 custservice@cultec.com www.cultec.com (800) 428-5832 or (203) 775-4416	**StormChamber** P.O. Box 672 Occoquan, VA 22125 Info@hydrologicsolutions www.hydrologicsolution.com (703) 492-0686

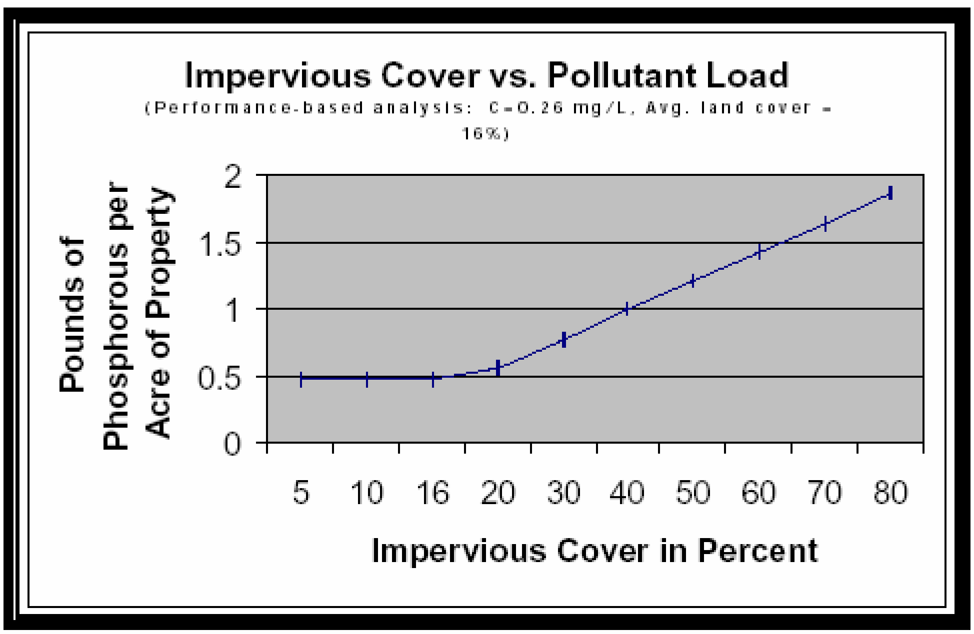
Technical Bulletin No. 4

Virginia Department of Conservation and Recreation – Water Quality Criteria

<u>Performance and Technology-based Approaches to Water Quality Assessment</u>

The Virginia Stormwater Management Regulations (SWMR) now reference both a performancebased and a technology-based criterion for water quality assessment. The performance-based criteria, based on the Simple Method (Refer to **Chapter 5-10** of the Stormwater Management Handbook), has been in use for the purposes of pollutant calculations and BMP implementation as required by the Chesapeake Bay Preservation Act (CBPA). The technology-based method, based on the simplistic approach of implementing what is considered to be the most appropriate Best Management Practice (BMP), or technology, for the specific development conditions, has been in use as basic compliance with the SWMR. The 1998 amendments to the SWMR have enhanced the technology approach so as to provide detailed specifications and design features necessary to promote BMPs which are more easily maintainable and more functional in the long-term. The result is a dual water quality criterion which allows for innovation in complying with the CBPA and the SWMR.

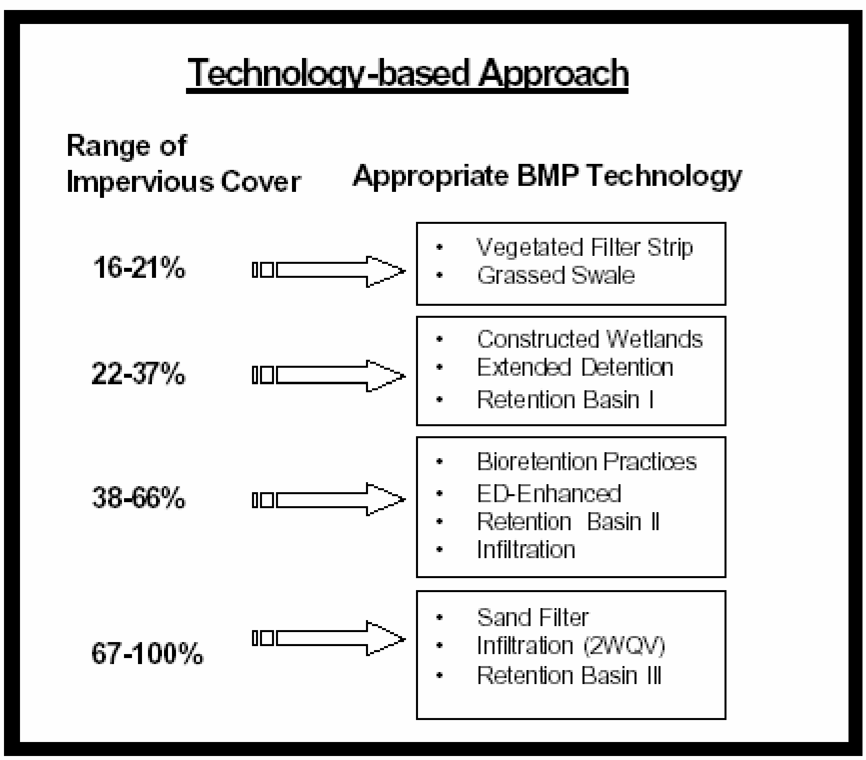
The performance-based approach is a simplistic method for associating pollutant loads with the percentage of impervious cover, based on a given pollutant loading concentration. The method assumes the amount of runoff, and the corresponding pollutant loads, are directly proportional to the degree of impervious cover. BMPs with given pollutant removal efficiencies are applied to the site to reduce post-development loads to pre-development levels associated with an average land cover condition, or default. (The reader is encouraged to refer to **Chapter 5-10** of the SWM Handbook for additional discussion of the criteria.)



The technology-based approach is an option whereby the designer, based on the characteristics of the site (drainage area size, total impervious cover, engineering constraints, etc.), selects a BMP which is the most technologically appropriate solution to reduce post-development pollutant load.

The detailed BMP standards and specifications referenced in the Virginia SWM Handbook are required elements necessary to achieve the referenced target pollutant removal efficiency. The intent is to shift the focus of BMP selection and design from debates over a few percentage points worth of pollutant removal efficiency to a new focus on the application of the most appropriate treatment technology for the site.

This approach assumes that the designer will apply sound engineering principles and specifications to the site design will do everything practicable to reduce the pollutant loads through site design enhancements and configuration. The technology-based criteria is most applicable in situations where the percentage of impervious cover is high such that multiple BMPs in series would be necessary to achieve the total pollutant load reduction required by the performance-based criteria. Inherent in the technology-based approach is the recognition that the application of BMPs in series will often yield little additional pollutant removal benefits (due to redundant removal pathways which target the same pollutants) versus a properly designed and maintained primary BMP with design enhancements, such as pretreatment of the runoff, and a minimization of loads generated on the site.



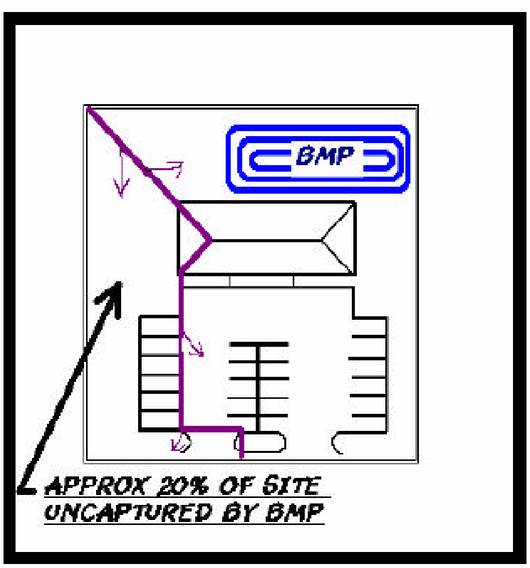
There are some limitations to the application of the technology-based approach. This method may not provide the most appropriate water quality assessment in situations such as the following:

- Multiple drainage areas on a site (not individually treated by the technology approach);
  - When multiple BMPs are employed to obtain compliance with a Regional (watershedwide) Stormwater Analyses;
  - Sites which include: buffer equivalency calculations, redevelopment, subdivided parcels, etc.

In such instances, the performance-based approach should be employed.

The goal of providing two technical criterion for water quality assessment is to encourage localities to allow reasonable adjustments to BMP efficiencies in order to provide some latitude for a wellthought out BMP plan. An unintended result is that some designers may examine the results of each method and then select the one which is least restrictive for the development being analyzed. While the two methods will generally provide similar overall results and likewise a similar degree of waterquality protection, there may be cases where the results of such a comparison will favor one method over the other. In general, the performance-based method arrives at the result through an analytical, pollutant load and removal efficiency calculation process, and the technology-based method arrives at the result through a detailed set of specifications for Best Management Practices suited for the specific physical characteristics of the site.

The following example problem provides comparitive insight as to the proper interaction and application of the two methods.



• ***Situation:*** **A 3-Acre new development site will be developing from the 16% average land cover condition (assumed) to a 60% impervious cover condition. Only 80% (approximately) of the total site area can be easily captured within the proposed BMP system.**

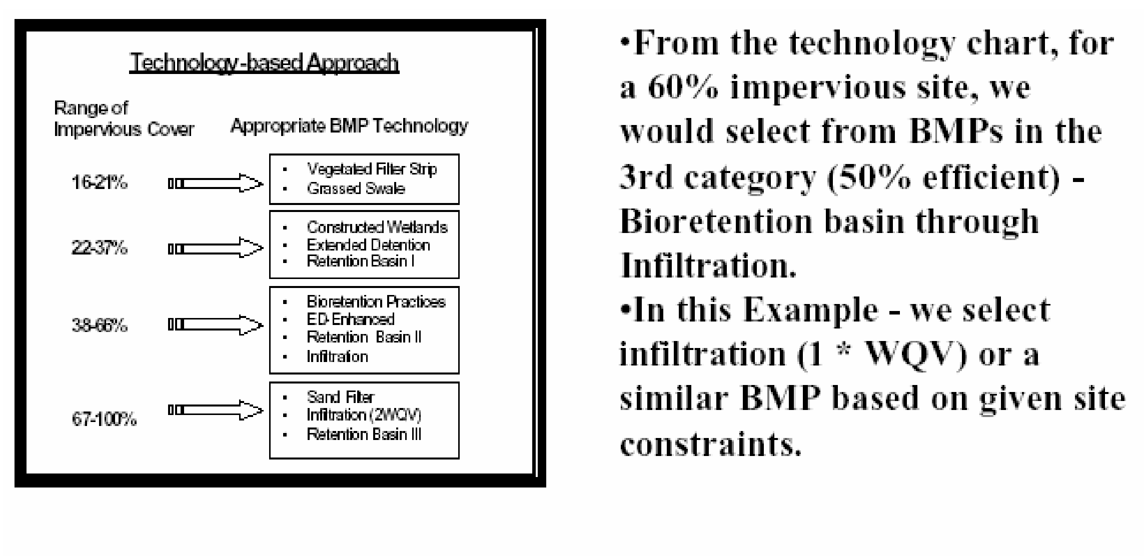
• ***Goal:*** **Compare the Effectiveness of Performance vs. Technology-based approach**

Performance Based Approach
(Pollutant loading calculations)

Under the performance based approach, we calculate the pre and post-development loads based on the assumed pre-development impervious cover equal to the average land cover (in this case 16%), and the actual post-development impervious cover.

The calculated required BMP removal efficiency is approximately **67%**.

Technology based approach



BMP Design

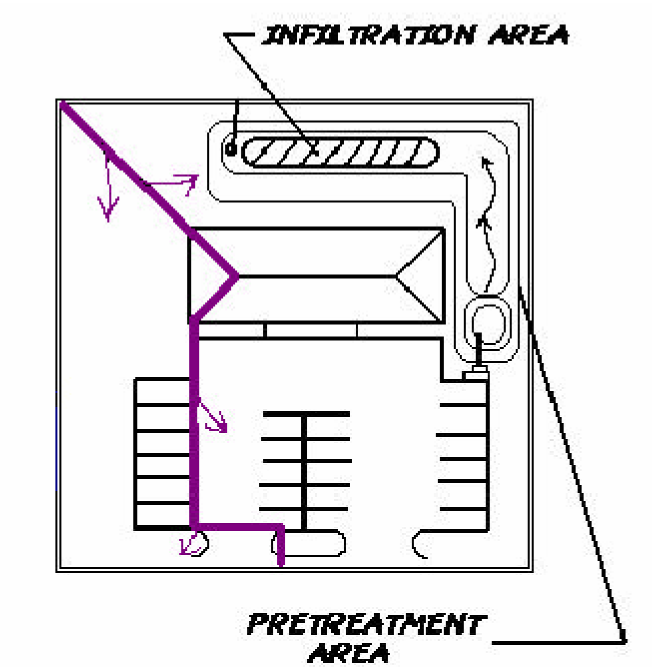
- Through the performance-based approach, we would be required to install either a single BMP or a series of BMPs to achieve a net 67% removal rate.

- Through the Technology-based approach, we select an infiltration measure for the primary BMP. As this BMP is approximately 50% efficient, and is treating approximately 80% of the site area, we have a net 40% pollutant removal. Guidance in this matter states that we should provide a secondary BMP of some kind to treat the portion of the site which is not captured by the primary BMP, so it does not run off unchecked.

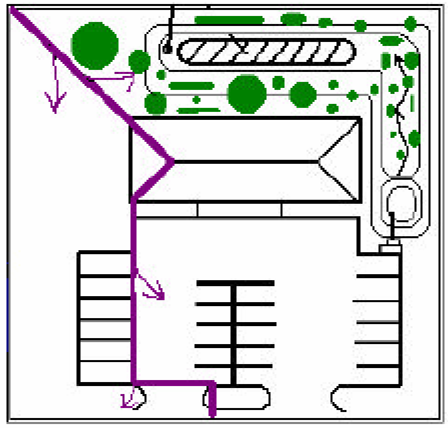
Question: How do we rectify this apparent discrepancy between the performance-based approach and the technology-based approach (67% removal required vs. 40% removal affected) ?
Answer: Sound technical specifications. The BMP standards and specifications for an infiltration BMP (an infiltration BMP is mentioned here in keeping with the above

example, however, the same can be applied to any number of different BMPs) require that pretreatment measures, a landscape plan for the site and BMP buffer areas, and possibly a second BMP treating the remaining 20% be provided. The application of all these design features and enhancements will typically generate a BMP plan sufficient to meet the performance-based requirements.

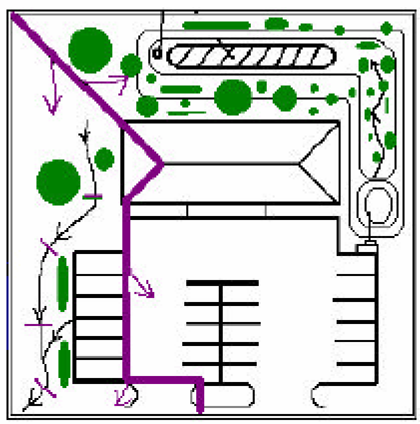
Pretreatment: Pretreatment is a necessary facet of most BMP plans. It helps to ensure long-term functionality of a BMP, assists in lowering maintenance costs, and generally increases their effectiveness in removing pollutants. In this case we provide a sediment forebay/marsh area near the discharge point, coupled with a meandered trapezoidal grassed swale with check dams. Under the technology-based approach, such pretreatment measures are required outright. Under the performance-based approach, a credit for additional pollutant removal for the grassed swale and forebay/ marsh is provided.



Landscaping: A landscape plan is an integral component of a BMP Plan. Not only does landscape assist with aesthetic concerns, a properly designed and maintained landscape plan can increase pollutant removal efficiency. In this example we have provided some vegetation in mulched landscape beds in the BMP pretreatment area, which will also provide some limited biofiltration capacity. We have also provided mulched landscape beds behind the proposed structure to filter the runoff, and remove larger particulate matter prior to entry into the basin. Whereas such a landscape plan is again, required outright under the Technology-based approach, the designer could claim additional pollutant removal benefits in the form of a limited filter strip, or biofiltration under the performance approach.



Additional Treatment: As stated previously, areas not captured by the primary BMP should not go untreated. A secondary BMP in the form of additional landscaping and a grassed swale with check dam has been provided in the smaller drainage area. While such additional treatment is required outright by the Technology approach, the designer could claim credit for additional treatment affected through this BMP.



Summary

- The technology-based approach is a simpler approach to traditional BMP selection, but is accompanied by stringent standards to promote high quality Best Management Practices.

- The technology-based approach requires that adequate technology be placed on the site to provide a level of treatment consistent with the density of the development.

- The intention of the technology based standard is to implement sound site and BMP designs based on the most appropriate technology.

- The local program administrator can require pretreatment and landscaping either through the multiple BMP requirements necessary to accomplish the required load reductions, or through the technology-based approach as a technical component of an efficient BMP design.

- The performance-based removal efficiencies for water quality BMPs can be marginally adjusted for very good designs which incorporate pollutant removal enhancement features such as sediment forebays, baffle systems to prevent short-circuiting, additional extended detention features, aquatic benches, micropools, etc. Likewise, the technology-based approach implements a BMP as a starting point with similar enhancement features required in order to provide the target removal efficiency.

Minimum Standard 3.11C
Filterra™ Bioretention Filter System
(revised 11/01/02)

Definition

The Filterra™ treatment system is a manufactured bioretention stormwater best management practice (BMP) that filters stormwater runoff from impervious surfaces (roadways, parking lots and roof tops). The Filterra™ treatment system consists of a concrete container filled with an engineered soil filter media, a mulch layer, an under-drain system and a tree, shrub or other plant selection. This filtration system can be integrated into the site design of both new development and redeveloped projects. Runoff drains directly from the impervious surface, through the filter media, and then out of the container through the under drain system to be discharged to a receiving system or infiltrated into the surrounding soil.

Purpose

Filterra™ is designed to be a water quality filter device to remove a wide range of nonpoint source pollutants from urban runoff in the same manner as bioretention practices (refer to **Minimum Standard 3.11: Bioretenion Practice**s). Pollutants are efficiently removed by a complex combination of physical, chemical and biological processes within the mulch, soil particles, microorganisms, and the plant materials.

Filterra™ can serve as a water quality BMP in areas where discharge of stormwater runoff into the sub-soils is not desired (e.g., gas stations and karst soils). An under drain system is used to convey filtered runoff to an adjacent drainage system. Where soils are permeable and ground water recharge is desirable Filterra™ can be designed to infiltrate highly treated water into the subsurface. It can be used as a filter only or as a combination filter and infiltration device. Filterra™ is generally not used for attenuation of large volumes of runoff for stream channel erosion control and flood control purposes. However, some degree of volume / flow reduction can be achieved by combining this filter system with an adjacent under ground storage / detention system (gravel trench or pipes). Such a combined system may be useful for urban retrofit projects to address problems associated with combined sewer overflows or for stream protection.

Conditions where Practice Applies

Filterra™ takes up little space (surface area or depth) and can be used in any type of urban or suburban commercial, industrial or residential development. Filterra™ is a suitable device for urban retrofit due to its flexible design, sizing criteria and concrete container and easy drop in place construction, it can be installed within the green space or streetscapes of redevelopment projects. Filterra™ can be modified to fit any curb line as a drop inlet along roadways, parking lots, or pedestrian plaza areas, **See Figure 1.** An adjacent drainage conveyance system is necessary in order to connect the under-drain system, and accept large storm bypass flows.

Figure 1. Filterra™ Urban Streetscape Design

It is designed to be used where runoff is likely to contain high concentrations of urban pollutants such as heavy metals, oil, and organics (such as gas stations, maintenance facilities and roadways). The system can be used alone or in combination with other BMP's. When used alone, pretreatment is not necessary as the system is designed to operate effectively without clogging from typical urban runoff concentrations of sediment and other particulate matter. The nature of the surface mulch and engineered filter media is such that particles become entrained into the mulch / filter media itself without clogging at the surface. The plant root system also keeps the soil open and free from clogging. As long as the manufacturer's operating and maintenance procedures are followed the filter device is projected to work for 20 years or more without replacement of the filter media or plant material.

Planning Considerations

Site Conditions

The enclosed non-permeable concrete container makes Filterra™ suitable for situations where infiltration is undesirable or not possible. These situations would include: karst topography, high groundwater conditions, close proximity to buildings, steep slopes, contaminated soils, brownfields sites, highly contaminated runoff or where chemical or oil spills are likely (maintenance facilities, industrial and gas stations). For "hot spots" where chemical spills are likely, the system can be fitted with a valve to quickly close the discharge drain pipe isolating the spill in the concrete container and filter media for easy cleanup, removal and replacement.

Where Filterra™ is being used to provide a combination of filtration and infiltration into the adjacent soils, planning considerations should include unique site conditions such as soil permeability, seasonal high groundwater table, depth to bedrock, karst topography, etc. Soil permeability will determine the degree to which it can be used as an infiltration device. For further discussion on planning considerations for infiltration practices, refer to the planning considerations described in the **General Infiltration Practices, Minimum Standard3.10, and Bioretention Basin Practices, Minimum Standard 3.11.**

<u>Developed Conditions</u>

Filterra™ is highly adaptable and can be used for most developments. Since the filter is contained in a concrete box it can be built in and around roadways sidewalks buildings and parking lots. It can be installed on many slope conditions typical of parking lots and roadways. In highly urban areas it is possible to use it in the design of an entire streetscape converting the typical non-functional streetscape into one large vegetated filter treatment device.

<u>Location Guidelines</u>

Filterra™ is best incorporated into the overall site, or streetscape or parking lot landscaping plan. The individual box locations represent a combination of drainage considerations (based on final grades and water quality requirements), desired aesthetics, and minimum landscaping requirements, and must be coordinated with the design of the drainage infrastructure.

<u>Aesthetic Considerations</u>

Aesthetic considerations must be evaluated early in the site planning process. While topography and hydraulic considerations may dictate the general placement of each structure, overall aesthetics of the site should be integrated into the site plan and stormwater concept plan from their inception. Both the stormwater engineer and the Landscape Architect must participate during the layout of facilities and infrastructure to be placed on the site.

<u>Sediment Control</u>

<u>Similar to bioretention basins and sand filters, Filterra™ if installed prior to full site stabilization and without proper inlet protection will become choked with sediment from upland construction operations, rendering it inoperable from the outset. Simply providing inlet protection or some other filtering mechanism during construction will not adequately control the sediment. One large storm may completely clog the soil media, requiring immediate maintenance.</u>

Filterra™ should be installed AFTER the site work is complete and stabilization measures have been implemented. (External and adjacent drainage and conveyance systems are typically built along with the site utilities and other infrastructure, and later connected to the boxes when installed. If this is not possible, strict implementation of E&S protective measures must be installed and maintained in order to protect the filter media from premature clogging and failure.

<u>Sizing Guidelines</u>

In general, bioretention has proven successful in part because of the relatively small surface area, low construction costs and ease of maintenance. Filterra™ provides these same benefits.

The current **Minimum Standard 3.11: Bioretention Practices** establishes a target ratio of bioretention surface area to contributing impervious area of 2.5%. The manufacturer of Filterra™ in cooperation with the University of Virginia has conducted research to optimize the flow / pollutant removal characteristics of the filter media to significantly reduce this ratio. The patented filter media has both high flow rates and high pollutant removal capabilities. To establish the sizing criteria the manufacturer has examined the rainfall distribution and frequency data from the mid-Atlantic region to size the filter surface area to treat 90% of the total annual rainfall volume. Pollutant removal data was also related to the filter surface area and drainage area relationships. The optimum filter surface area to drainage area ratio is 0.33%. For example, the required minimum size filter for ¼ acre of impervious surface would be 36 square feet of filter surface area or one 6 ft. by 6 ft. filter box.

The pollutant removal rates for Filterra™ also vary as a function of the filter surface area to drainage area. At the minimum 0.33% ratio filtering 90% of the annual runoff the expected pollutant removal rates are shown below. It is not recommended that a ratio of less than 0.33% be used.

Expected Pollutant Removal (@ 0.33% filter surface area / drainage area)
Total Suspended Solids Removal = 85%
Total Phosphorous Removal = 74%
Total Nitrogen Removal = 68%
Total Metal Removal = 82%

Higher pollutant removal rates are possible by increasing the ratio of filter surface area to drainage area. See the manufactures detailed calculations for sizing and pollutant removal on their web site at: http://www.americastusa.com/filterra.html. Local jurisdictions may want to consider achieving the highest pollutant removals possible to protect water supplies (surface and ground water) or sensitive water bodies and streams. This may be achieved with Filterra™ by increasing the filter surface area to drainage area ratio.

However it is well documented that the pollutant removal efficiency of a filter device varies with the concentration of pollutants in the inflow (the higher the pollutant levels are in the inflow the higher the pollutant removal rates will be). In order to account for this variability in efficiency, the maximum allowable pollutant removal rates for Filterra™ are as follows:

Maximum Pollutant Removal Rates
Total Suspended Solids Removal = 90%
Total Phosphorous Removal = 80%
Total Nitrogen Removal = 65%
Total Metals Removal = 85%

The above guidance on calculating pollutant removal is based on review of the manufacturer's laboratory data and the best available existing body of data on bioretention systems. However, these removal rates are subject to continuing review, and evaluation of future monitoring data. These pollutant removal rates may be modified on a periodic basis by DCR as determined by ongoing field testing and future improvements to the Filterra™ system. *

Design Criteria

General

The design of Filterra™ shall be in accordance with manufacturers specifications. The designer is not only responsible for selecting the appropriate components for the particular design but also for ensuring long-term operation.

Soils Investigation

When infiltration into the surrounding subsoil is desired, refer to the **Planning Considerations and Design Criteria of General Infiltration Practices, MS-3.10**, and to local jurisdiction soil study requirements such as **Chapter 5, Section V. of the *Northern Virginia BMP Handboo*k**. A minimum of one soil boring log should be required for each structure where infiltration is considered.

Sizing Methodology

The designer must verify that Filterra™ has been sized and installed in accordance with the manufacturer's specifications. The distribution and sizing of the system of filters should be in accordance with the manufacturer’s recommendations to achieve the most cost-effective treatment practicable while satisfying the performance-based or technology-based water quality criteria. Typical development / redevelopment streetscape or parking lot design will use a minimum of one 6’x6’ filter box in an off-line configuration for every ¼ of drainage area, or a combination of boxes so as to maintain a 0.33% ratio of filter surface area to drainage area.

When designing the system, consideration must be given for overflows during major storm events. Once the filter flow capacity is exceeded a backflow condition develops forcing runoff to by-pass the filter. Overflows should be diverted to a safe conveyance device (inlet, swale or green space).

Pretreatment

Pretreatment is generally not necessary as the filter’s media, mulch and plant root system is designed to operate without clogging under normal conditions. Routine annual inspection and maintenance will ensure that the filter will operate for at least 20 years. Normal conditions mean a stabilized drainage area with typical concentrations of sediment and other urban pollutants. Follow the manufacturer's recommendations for unusual site conditions where high pollutant loads are expected. If it is installed when there is active construction within the drainage area the opening to the filter should be blocked off. Follow the manufacturer's recommendations on protection of the filter box and media during construction activities.

Observation Well and Clean-out

Filterra™ is typically delivered to the site completely assembled or assembled by the manufacturer at the site. The system comes with an observation well installed that can also be used as a clean out to remove any blockages in the under drain piping.

Plant Materials

The plant materials used for Filterra™ should follow the manufacturer's recommendations. Generally, the manufacturer will provide and install the filter material and plants. The system can use typical readily available landscape plant materials. It is designed to use upland plants not wetland plants. Filterra™ provides a hydrologic regime where wetland plants will not survive and should not be used. The plants used for bioretention will also work for Filterra™. **See Minimum Standard 3.11a Bioretention Basin Practices.** One of the advantages of this system is that it uses commonly available nursery stock plant materials so the end user can select from a wide range of plants to also achieve aesthetic and habitat values. The types of plants used will also determine the depth and design of the concrete container. The standard 6' x 6' box is designed to accommodate a typical shrub, herbaceous material or a very small tree. If a standard street tree is used, the filter box must be larger to accommodate the larger root system, prevent wind throw and to ensure adequate filter surface area as the tree matures. A 9' x 12' box would be the minimum size needed for most street trees. In some cases the manufacturer may recommend a customized box size and configuration to accommodate special plant requirements, unique site conditions, water quality protection goals and ensure adequate performance.

It is not recommended that one filter be used to treat very large volumes of runoff from a large drainage area. Runoff should not be detained and stored in a holding tank to be metered out to the filter media over a long period of time. Exposing the soil, microbes and plants to prolonged and frequent flooding and wet conditions will significantly change the hydrologic regime reducing the effectiveness of the media to capture pollutants and the microbe's / plant's ability to cycle nutrients, break down organics and uptake heavy metals. Therefore, continuous or frequent flows (such as basement sump pump discharges, cooling water, condensate water, artesian wells, etc.) MUST BE EXCLUDED from routing through the system. If the filter media remains water logged for 3 or 4 days anaerobic conditions will develop dropping both oxygen and pH levels which may kill desirable soil microbes and the plants. Filterra™ is an upland system that must periodically dry out to maintain aerobic conditions to ensure the productivity and vigor of the microbes and plants. The unique filtering system approach of designing for small drainage areas and distributing the filters uniformly throughout the site ensures that the filter drains properly in about one hour to maintain aerobic conditions and enable the filter to be ready to accept the next rain storm event in just a few hours. Follow the manufacturer's recommendations on sizing and distribution of the filter boxes as deviations from the manufacturer's specifications may void any manufacturer's warranty and significantly reduce the ability of the filter to perform properly.

Construction Specifications

Accepted construction standards and specifications should be followed where applicable. Specifications and the work should conform to methods and procedures applicable to the installation of a prefabricated concrete box such as an inlet or other type container structure. The construction specification of the concrete container or use of an alternative material for the container should comply with the recommendations of the manufacturer and all applicable standards by the local or state approval authority.

Sequence of Construction

Filterra™ can be constructed and installed at any convenient time during the construction of the site or after the installation of the site's infrastructure as a "drop in place" devise. However, it should not be placed in service until the contributing drainage area has been stabilized. If the device is installed during the construction of the site's infrastructure, the inlet opening must be protected from sediment. Follow the manufacturer's recommendations on sediment /erosion protection.

The specification for the construction of the system should state the following: 1) the earliest point at which the runoff can be safely directed to the device and 2) the means by which this "delay in usage" is to be accomplished. When the device is made operational will depend on a variety of unique site conditions and should be evaluated and determined on those conditions.

Excavation

When Filterra™ is to be used in conjunction with or as an infiltration device the preparation of the infiltration trench placement and type of stone used or filter fabric should conform to the **Construction Specifications of on Infiltration Trenches: Minimum Standard 3.10B.** Placement of the filter box should be on an acceptable base (gravel, sand or compacted soil) to prevent the device from settling. The filter container should be backfilled and compacted in the same manner as any precast concrete structure. The under drain leaving the box and connecting to the receiving conveyance system should be appropriately supported to prevent deflection during backfilling operations and sealed at the connection points to prevent leakage.

Maintenance and Inspection Guidelines

The manufacturer provides for the inspection, care and maintenance of the Filterra™ device for the first two years. After this initial two year period, the owner / operator of the system should follow all of the manufacturer's maintenance and inspection guidelines. In general, annual routine inspection and maintenance activities required are of a similar nature to any landscaped area and would include removal of trash, debris and sediment, replenishment of the mulch, and care or replacement of plants. The plant material requires no special care or attention once it has acclimated. Annual maintenance and care of the plants in a 6'x6' FT may require using one bag of mulch, a hand full of allpurpose fertilizer (optional) and 20 minutes of time. Fertilization of the plants is optional since the system receives adequate nitrogen, organics and phosphorus from the runoff. During extreme droughts the plants may need to be watered in the same manner as any other landscape material. In the event of a chemical spill all of the soil and plants should be removed and properly disposed and replaced with new uncontaminated filter media and plants.

Manufacturer Contact:
Mr. Terry Siviter
Americast Inc.
Phone: 804 798 6068 / Web site: www.americastusa.com

Minimum Standard 3.02: Principal Spillways
High Density Polyethylene (Plastic) Trash Racks

Definition

Trash Racks are cage like attachments used on stormwater impoundment riser or outlet structures. High density polyethylene (plastic) trash racks are made from structural plastic consisting of a cellular core surrounded by integral skins forming a totally integrated structure. Structural molded parts are made from 100% virgin High Density Polyethylene (HDPE) and fiberglass.

Purpose

Trash racks are used to prevent floating and particulate debris from clogging outlet control structures. The goal is to trap material on the outside of the structure where it can be easily removed. Once debris enters a riser structure it can get lodged inside the riser and/or outlet barrel. Low flow trash racks are designed to keep sediment and other small debris from entering and clogging the low flow pipe. Riser trash racks are larger with a spacing that allows small debris to pass through while keeping large debris such as tree limbs, lumber, and other large materials out of the structure.

Conditions Where Practice Applies

Trash racks are required on most stormwater management impoundment structures with a riser or barrel (or combination). In addition, an anti-vortex device may be required if the design high water of the facility exceeds the weir flow capacity of the principal spillway. **(Refer to the complete text of Minimum Standard 3.02**).

Planning Considerations

Most basins will collect a certain amount of trash and debris from incoming flows. Floating debris such as grass clippings, tree limbs, leaves, trash, construction debris, and sediment bed load from upstream watersheds are common. Therefore, all control structures, including detention, extended-detention and retention basin low-flow weirs and orifices should have a trash rack or debris control device. A trash rack will collect this debris in plain sight which will encourage maintenance as needed (as opposed to debris collecting unseen inside a structure with no apparent problem until the structure becomes completely clogged). Failure to keep a riser structure clean can greatly diminish the flow capacity possibly resulting in overtopping of the embankment.

In an effort to reduce the required frequency of maintenance, the Virginia Stormwater Management Handbook requires principal spillway structure trash racks to be designed as non-clogging. At a minimum this requires a sloped or vertical trash rack surface, or a birdcage type design with vertical spacing between the top of the horizontal trash rack and the riser top. (Refer to the following figures as examples of acceptable trash rack designs.)

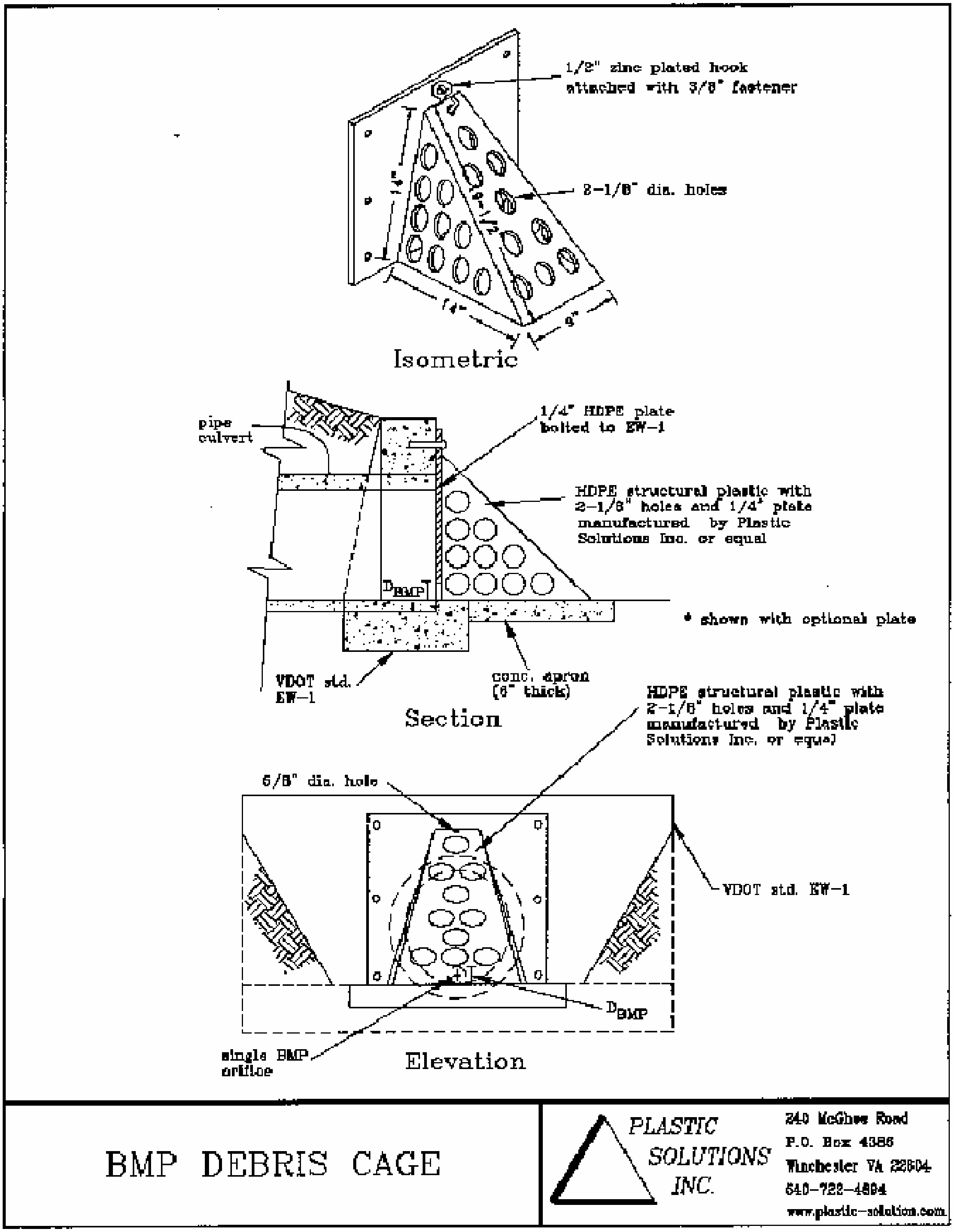
Design Criteria

Plastic Solutions, Inc. has developed and field-tested trash racks made from structural plastic. A full line of trash racks and debris cages has been manufactured to accommodate almost any storm water management basin or pond structure. Plastic Solutions, Inc. offers a full line of standard sizes, but can customize to specific requirements. Racks are designed to fit concrete, metal and plastic pipe.

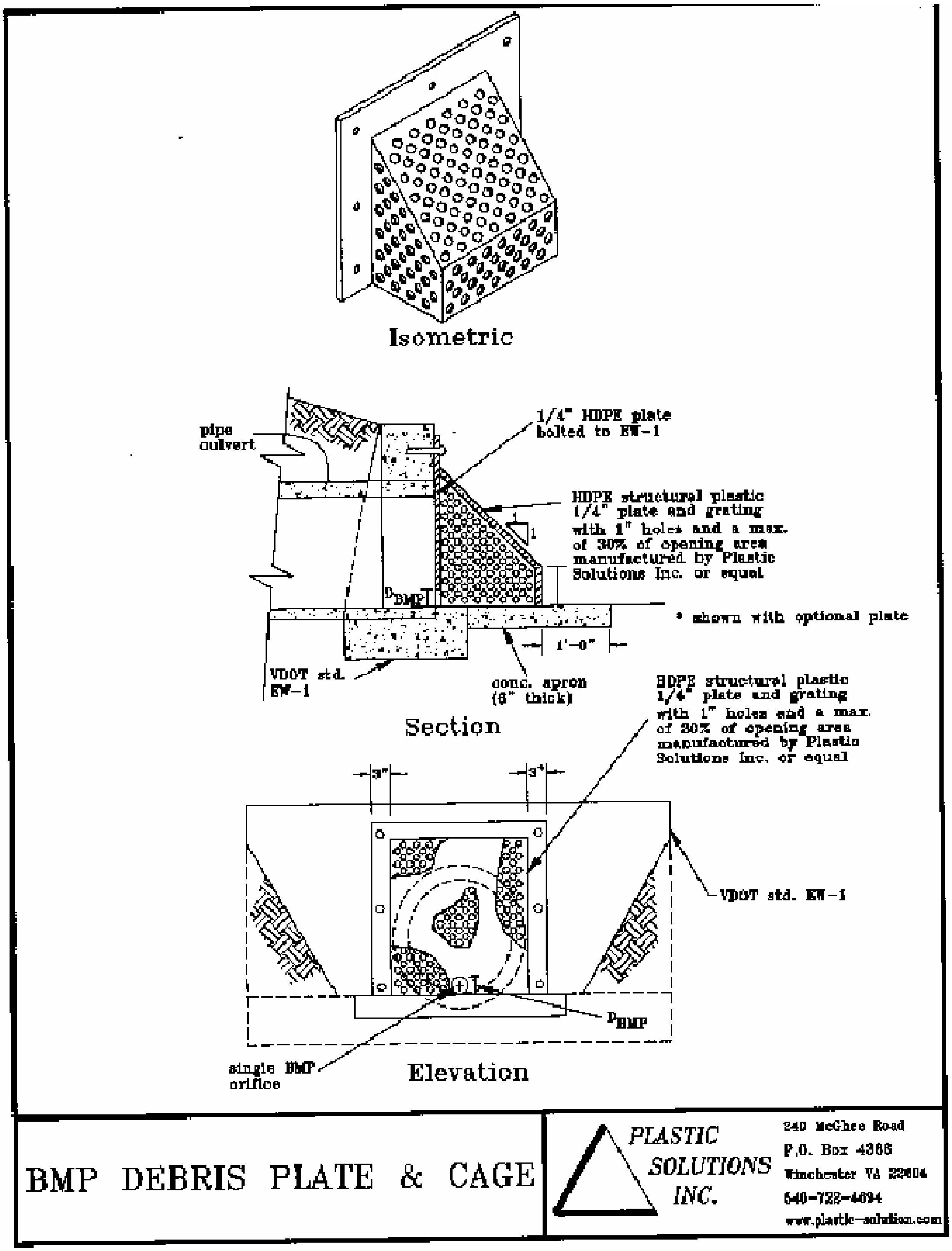
Plastic racks have many advantages to the conventional steel racks. They are much lighter and can be installed without the use of heavy equipment. Plastic racks are chemical resistant and will not rust or corrode. After installation, they are maintenance free.

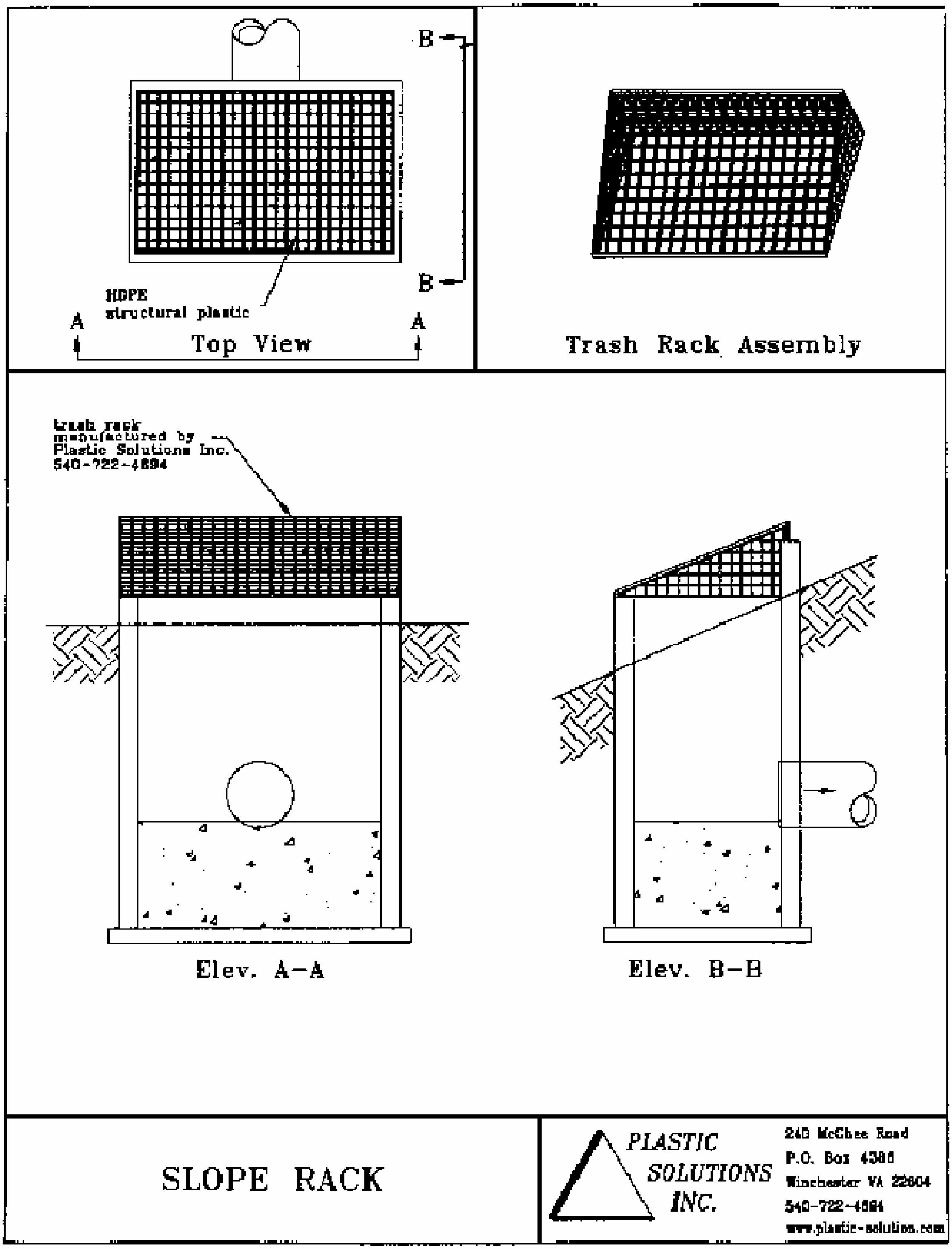
The Virginia Department of Transportation has approved the Plastic Solutions pyramid style racks as an alternative to the DI-7 cover and the plastic debris rack as an alternative to the metal fabricated rack.

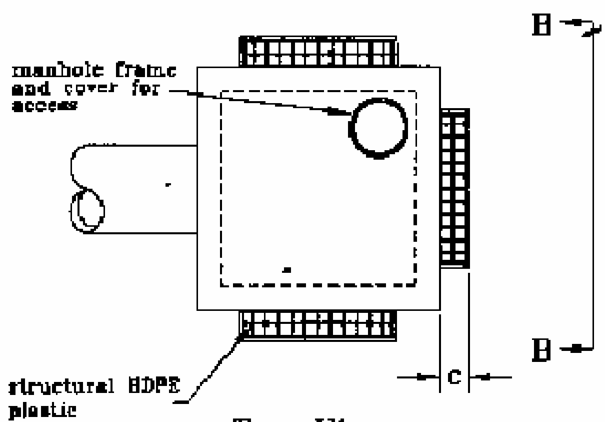
The reader is encouraged to visit the manufacturers web site at www.plastic-solution.com for additional information.



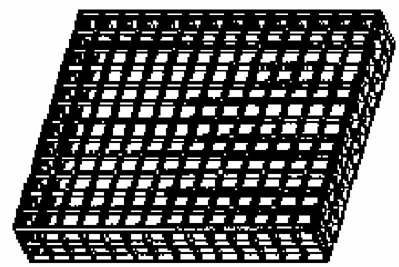
1/2" zinc plated hook attached with 3/8" fastener
2-1/8" dia. holes
14"
9"
Isometric
1/4" HDPE plate bolted to EW-1
pipe culvert
HDPE structural plastic with 2-1/8" holes and 1/4" plate manufactured by Plastic Solutions Inc. or equal
D BMP
* shown with optional plate
VDOT std. EW-1
conc. apron (6" thick)
Section
HDPE structural plastic with 2-1/8" holes and 1/4" plate manufactured by Plastic Solutions Inc. or equal
5/8" dia. hole
VDOT std. EW-1
D BMP
single BMP orifice
Elevation
BMP DEBRIS CAGE
PLASTIC SOLUTIONS INC.
240 McGhee Road
P.O. Box 4386
Winchester VA 22604
540-722-4894
www.plastic-solution.com


Isometric
pipe culvert
1/4" HDPE plate bolted to EW-1
HDPE structural plastic 1/4" plate and grating with 1" holes and a max. of 30% of opening area manufactured by Plastic Solutions Inc. or equal
* shown with optional plate
1'-0"
VDOT std. EW-1
conc. apron (6" thick)
Section
HDPE structural plastic 1/4" plate and grating with 1" holes and a max. of 30% of opening area manufactured by Plastic Solutions Inc. or equal
3"
3"
VDOT std. EW-1
DBMP
single BMP orifice
Elevation
BMP DEBRIS PLATE & CAGE
PLASTIC SOLUTIONS INC.
240 McGhee Road
P.O. Box 4366
Winchester VA 22604
540-722-4694
www.plastic-solution.com

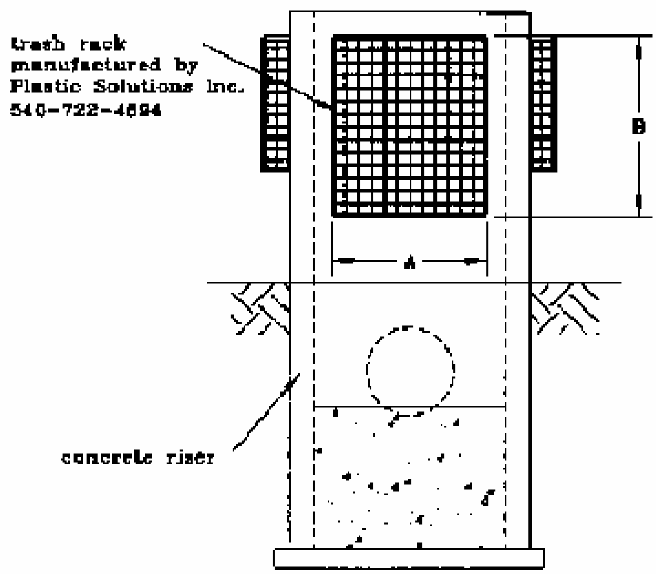

B
B
HDPE
structural plastic
A
A
Top View
Trash Rack Assembly
trash rack
manufactured by
Plastic Solutions Inc.
540-722-4694
Elev. A–A
Elev. B–B
SLOPE RACK
PLASTIC
SOLUTIONS
INC.
P.O. Box 4386
Winchester VA 22604
540-722-4694
www.plastic-solution.com



Top View



Trash Rack Assembly



Elev. B–B

A	11 3/8	16 3/4	22 1/8	27 1/2	33 7/8	38 1/4	43 5/8	49	54 3/8	59 3/4	65 1/8	71 1/8	76 1/2	81 7/8	87 1/4
width code	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
B	11 3/8	16 3/4	22 1/8	27 1/2	33 7/8	38 1/4	43 5/8	49	54 3/8	59 3/4	65 1/8	70 1/2	76 7/8	81 7/8	87 1/4
length code	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16

C	7 1/2	12 7/8
height code	01	02

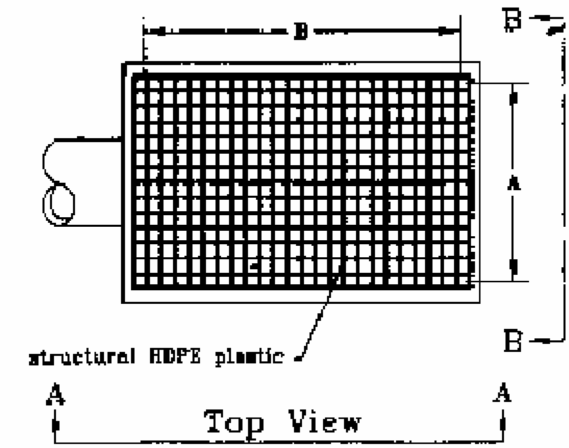
part code= fR + width code +length code + height code
(ex. FR080802)

NOTE: CUSTOM SIZES AVAILABLE UPON REQUEST

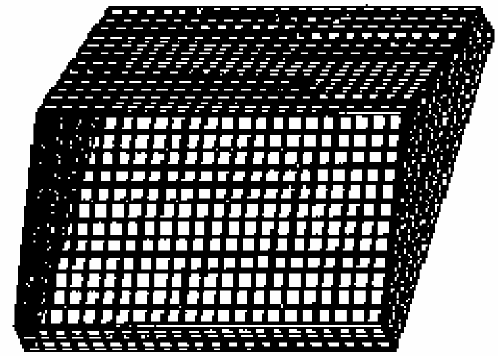
FLAT ROOF TRASH RACK

PLASTIC SOLUTIONS INC.

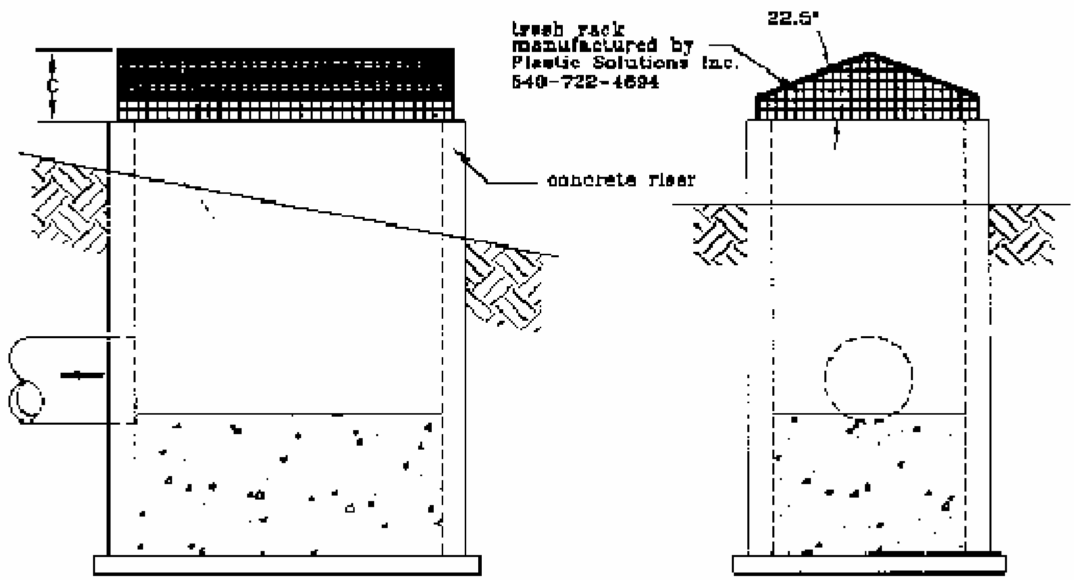
240 McGhee Road
P.O. Box 4300
Winchester VA 22604
540-722-4694
www.plastic-solution.com



Top View



Trash Rack Assembly



Elev. A–A

Elev. B–B

A	40 3/4	50 3/4	60 1/2	79 1/2	89 1/2	99 1/2	109 1/4	120 1/2
width code	10	12	14	16	18	20	22	24
C	16	20	22	24	26	28	30	32

B	49	54 1/2	59 3/4	65 1/4	70 1/2	76	82	87 1/4
length code	09	10	11	12	13	14	15	16

numbers rounded to 1/4"

part code= PR + width code +length code
(ex. PR1213)

NOTE: CUSTOM SIZES AVAILABLE UPON REQUEST

PEAKED ROOF TRASH RACK

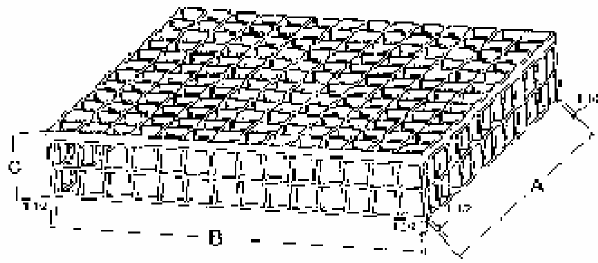
PLASTIC SOLUTIONS INC.

240 McGhee Road
P.O. Box 4365
Winchester VA 22604
540-722-4694
www.plastic-solution.com

FLAT ROOF RECTANGULAR RACKS/WEIRS

(Standard Sizes)

Dimensions in Inches to the Nearest 1/4"



STANDARD WIDTHS

A	11 3/8	16 3/4	22 1/8	27 1/2	32 7/8	38 1/4	43 5/8	49	54 3/8	59 3/4	65 1/8	71 1/8	76 1/2	81 7/8	87 1/4
Width Code	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16

STANDARD LENGTHS

B	11 3/8	16 3/4	22 1/8	27 1/2	32 7/8	38 1/4	43 5/8	49	54 3/8	59 3/4	65 1/8	70 1/2	75 7/8	81 7/8	87 1/4
Length Code	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16

STANDARD HEIGHT

C	7 1/2	12 7/8
Height Code	01	02

PART CODE = FR ______ ______ ______ (example: FR080802)

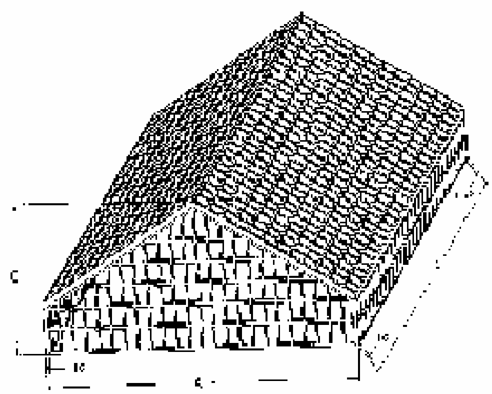
Width Code, Length Code, Height Code

**** CUSTOM SIZES AVAILABLE UPON REQUEST ****

PEAK ROOF STRUCTURE

(Standard Sizes)

Dimensions in Inches to the Nearest 1/4"



STANDARD WIDTHS AND HEIGHTS

A	49 3/4	59 3/4	69 1/2	79 1/2	89 1/2	99 1/2	109 1/4	120 1/2
Width Code	10	12	14	16	18	20	22	24
C	18	20	22	24	26	28	30	32

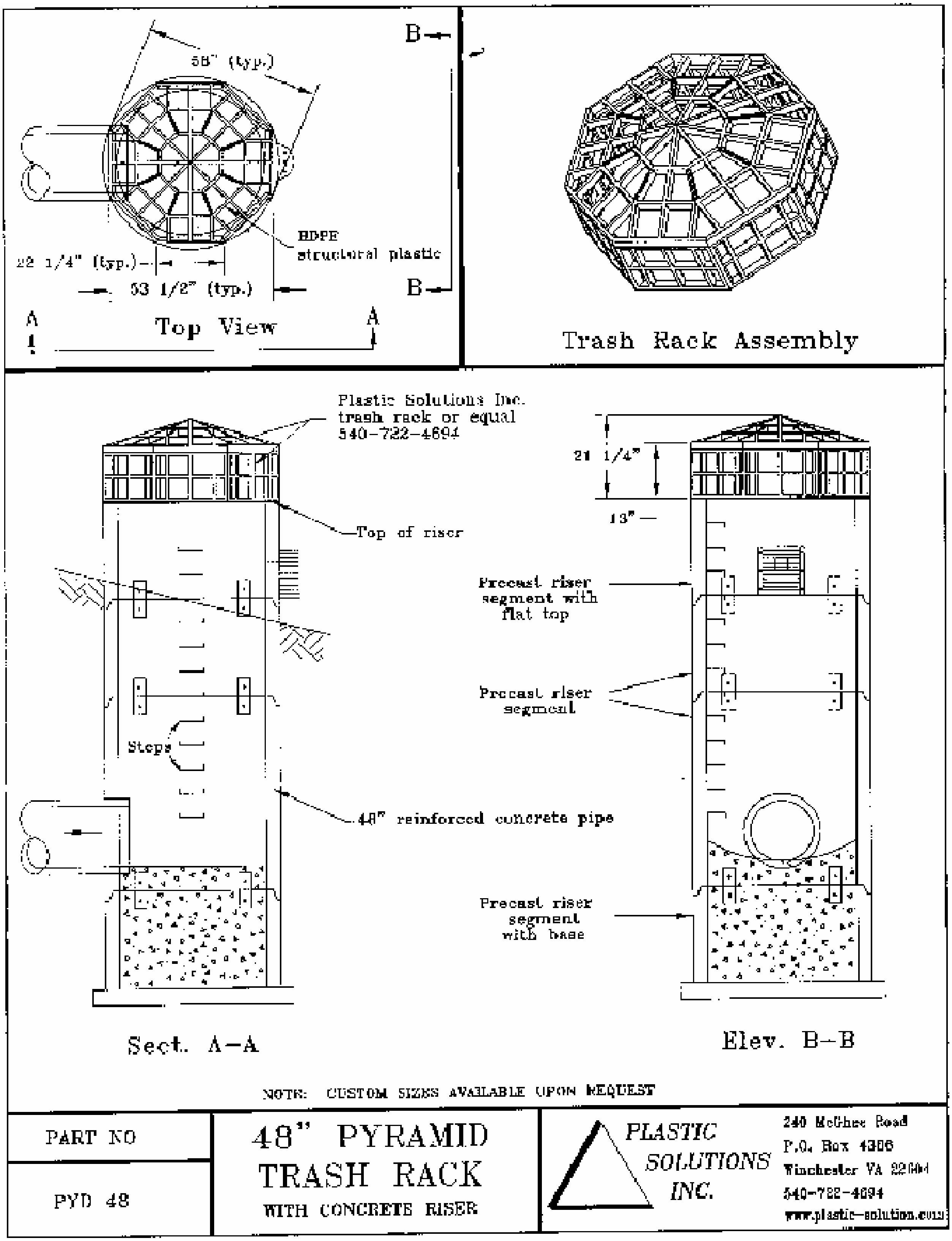
STANDARD LENGTHS

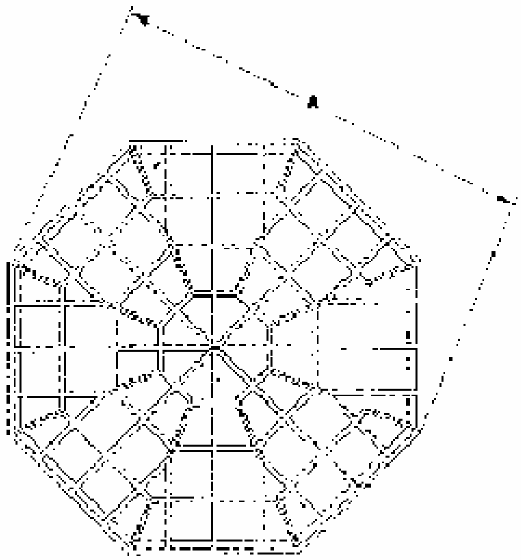
B	49	54 1/2	59 3/4	65 1/4	70 1/2	76	82	87 1/4	92 3/4	98	103 1/2	108 3/4
Length Code	09	10	11	12	13	14	15	16	17	18	19	20

PART CODE = PR ______ ______ ______ (example: PR12120)

Width Code, Length Code, Height Code

**** CUSTOM SIZES AVAILABLE UPON REQUEST ****


58" (typ.)
B
22 1/4" (typ.)
HDPE structural plastic
53 1/2" (typ.)
B
A
Top View
A
Trash Rack Assembly
Plastic Solutions Inc. trash rack or equal 540-722-4694
Top of riser
Steps
48" reinforced concrete pipe
21 1/4"
13"
Precast riser segment with flat top
Precast riser segment
Precast riser segment with base
Sect. A–A
Elev. B–B
NOTE: CUSTOM SIZES AVAILABLE UPON REQUEST
PART NO
PYD 48
48" PYRAMID
TRASH RACK
WITH CONCRETE RISER
PLASTIC SOLUTIONS INC.
240 McGhee Road
P.O. Box 4306
Winchester VA 22604
540-722-4694
www.plastic-solution.com



PYRAMID STRUCTURES

(STANDARD SIZES)

Dimensions in Inches to the Nearest 1/4"

Pyramid Racks for Concrete Pipe

Part No.	Pipe I.D.	Pipe O.D.	A	B	C
PYD-24	24	30	30	7 1/2	11 3/4
PYD-36	36	44	44	13	19 1/4
PYD-48	48	58	58	13	21 1/4
PYD 60	60	72	71	17 3/4	28
PYD 72	72	86	84	23 1/2	31 3/4
PYD-84	84	100	94 1/2	25 1/2	39 1/2
PYD-96	96	114	114	22 3/4	39 1/2

Pyramid Racks for Plastic and Metal Pipe

(Includes Fastening Kit)

Part No.	Pipe Corrugated	Pipe Plastic	A	B	C
PYDP-24	12,15,18	12,15,18	30	7 1/2	11 3/4
PYDP-36	21,24,27,30	24,30	44	13	19 1/4
PYDP-48	33,36,42	36,42	58	13	21 1/4
PYDP-60	48,54	48	71	17 3/4	28
PYDP-72	60,66	60	84	23 1/2	31 3/4
PYDP-84	72,78		94 1/2	25 1/2	39 1/2
PYDP 96	84,90,96		114	22 3/4	39 1/2

PLASTIC SOLUTIONS INC.

CAD Drawings Available from Our Website www.plastic-solution.com

P.O. Box 4386 • Winchester, VA 22604 • 540-722-4694 • 877-877-5727 • Fax: 540-722-2219